FINAL ENVIRONMENTAL STATEMENT FOR THE GEOTHERMAL LEASING PROGRAM

REPORT IN FOUR VOLUMES

I. PROMULGATION OF LEASING AND OPERATING REGULATIONS
II. LEASING OF GEOTHERMAL RESOURCES IN THREE CALIFORNIA AREAS
III. PROPOSED GEOTHERMAL LEASING AND OPERATING REGULATIONS
IV. COMMENTS ON DRAFT IMPACT STATEMENT AND PROPOSED REGULATIONS

Volume I of IV

PROMULGATION OF LEASING AND OPERATING REGULATIONS
FOR THE
GEOTHERMAL LEASING PROGRAM

U.S. DEPARTMENT OF THE INTERIOR

1973

DEPARTMENT OF THE INTERIOR

FINAL ENVIRONMENTAL STATEMENT FOR THE GEOTHERMAL LEASING PROGRAM

Prepared by

Office of the Secretary

Department of the Interior

FINAL ENVIRONMENTAL STATEMENT

FOR THE

GEOTHERMAL LEASING PROGRAM

Volume I of IV

Description of the Proposal
The Energy and Environmental Setting
Geothermal Energy Resources and Potentials
Development of Geothermal Resources
Description of the Environment
Promulgation of Leasing and Operating Regulations
Environmental Impact of the Proposed Action
Mitigating Measures Included in the Proposed Action
Adverse Impacts Which Cannot Be Avoided
Short-term Uses of the Environment and Long-term Productivity
Irreversible and Irretrievable Commitments of Resources
Alternatives to the Proposed Action

Prepared in Compliance With

Section 102 (2) (C) of the National Environmental

Policy Act of 1969

Prepared by

UNITED STATES DEPARTMENT OF THE INTERIOR

1973

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SUMMARY

Final Environmental Statement
Department of the Interior, Office of the Secretary

1. Administrative type of action

2. Brief description of action

The Secretary of the Interior is charged with the implementation of the Geothermal Steam Act of 1970 (30 USC 1001-1025(1970) which provides for the development of federally owned geothermal resources. Section 3 of the Act defines the public lands potentially available for geothermal leasing. These include principally: (1) public, withdrawn, and acquired lands administered by the Secretary of the Interior (approximately 451 million acres in 25 States); (2) national forests and other lands administered by the Forest Service, Department of Agriculture (approximately 187 million acres in 45 States and Puerto Rico); and (3) lands containing a reservation to the United States of the geothermal resources. These lands total 638 million acres. The most promising geothermal resource areas appear to be located predominantly in the 11 western States and Alaska.

Included in this proposed action are: (1) the promulgation of leasing and operating regulations pursuant to which the program would be administered; and (2) the leasing of federally owned geothermal resources for development in three specific areas: (a) Clear Lake-Geysers; (b) Mono Lake-Long Valley; and (c) Imperial Valley, all in California.

3. Summary of environmental impact and adverse environmental effects

Lands under consideration for geothermal leasing presently are subject to use for grazing, forestry, mining and other mineral production, fish and wildlife habitat, outdoor recreation, and watersheds.

Development of geothermal resources entails construction of access roads and well sites, drilling and testing of wells, conveyance of steam over short distances to electric power plants and by-product processing plants, construction and operation of electric power plants, by-products facilities, electrical transmission lines, and facilities for disposing of waste liquids.

Locally, land would be preempted or restricted from uses such as wildlife habitat, recreational use, grazing, etc. Terrain would be modified through construction of roads, wells, pipelines, and industrial facilities. Noise and noxious gaseous emissions could pose problems during testing and production. Possible adverse effects include land subsidence due to production of fluids and increased seismicity due to production and reinjection of fluid wastes into producing zones.

4. Alternatives considered

A. Alternative timing of actions
   (1) Do not initiate a leasing program
   (2) Delay pending additional environmental evaluation
   (3) Delay pending new or improved technologies
B. Alternative regulation environmental provisions
C. Alternatives for leasing of geothermal resources
D. Alternatives for exploration and development
E. Alternative sources for electrical energy

5. Comments have been requested and received from the following:

(See list next page)

6. Date made available to CEQ and the public:

Draft statement: October 6, 1971
Supplement to draft statement: May 3, 1972
Final statement: October 1973

Comments have been requested from the following:

Atomic Energy Commission
Department of Agriculture
Department of Commerce
Department of Defense
Department of the Army
Department of Health, Education and Welfare
Environmental Protection Agency
Federal Power Commission
State of Alaska
State of Arizona
State of California
State of Colorado
State of Hawaii
State of Idaho
State of Montana
State of Nevada
State of New Mexico
State of Oregon
State of Utah
State of Washington
State of Wyoming
Association of Bay Area Governments
Imperial County Administrator (California)
Lake County Administrator (California)
Mendocino County Administrator (California)
Mono County Administrator (California)
Sonoma County Administrator (California)
Sacramento Regional Area Planning Commission (California)
Southern California Association of Governments
Washoe County Regional Planning Commission (Nevada)

Comments have been received from the following:

Senator Alan Bible
Senator Mark Hatfield
Representative Craig Hosmer
Atomic Energy Commission
Department of Agriculture
Department of the Army
Department of Commerce
Department of Health, Education and Welfare
Department of the Interior
Environmental Protection Agency
State of Alaska
State of Arizona
State of California
State of Colorado
State of Montana

State of Nevada
State of Oregon
State of Utah
State of Washington
City of Los Angeles
Imperial County, California
ABT Association
Aidlin, Martin and Mamakos
American Public Power Association
American Thermal Resources, Inc.
Anadarko Production Co.
Birchan Corporation
California Farm Bureau Federation
Center for Law and Social Policy
Crego, William O.
Duke University
Dunn, Franklin
Economic Opportunity Commission of Imperial County, Inc.
Finn, Donald F. X.
Garrison, Lowell E.
Geothermal Resources International
Getty Oil Company
Gilmore and Gilmore
Groh, Edward A.
Gulf Oil Company
International City Management Association
Jessen, Frank W.
Lake County Geothermal Control Council
Mackay School of Mines
Magma Power Company
National Association of Counties
National League of Cities
National League of Cities, U. S. Conference of Mayors
Natomas Company
Occidental Petroleum Corporation
O'Neill, Joseph I.
Oregon Environmental Council
O'Rourke, John T.
Pacific Gas and Electric Company
Phillips Petroleum Company
Portland State University
Rowan, George D.
Rust Engineering Company
Sierra Club
Signal Oil and Gas Company
Simis, Mrs. Jan O.
Southern California Edison Company
Southern Pacific Land Company
Standard Oil Company of California
Sun Oil Company
Texaco, Inc.
Transcontinental Power Company

Trout Unlimited
Union Oil Company
University of California, Berkeley
Washington Environmental Council
Washington State Sportsmen's Council, Inc.
Western Geothermal, Inc.
Western Rockhound Association, Inc.

INTRODUCTORY NOTES, VOLUME I

This Final Environmental Statement consists of four volumes:

Volume I. Promulgation of Leasing and Operating Regulations

Volume II. Leasing of Federally Owned Geothermal Resources for Development in Three California Areas

Volume III. Proposed Regulations and Comments

Volume IV. Comments on Draft Impact Statement and Proposed Regulations

The Draft Environmental Statement for the Geothermal Leasing Program was released by the Department of the Interior on October 6, 1971. Notice of availability of the Draft Statement was published in the Federal Register, October 6, 1971. The notice also announced that public hearings were to be held in Reno, Nevada; Sacramento, California; and Portland, Oregon. The published notice announced that written comments would be received on the Draft Statement for a period of 45 days after the publication of the notice.

On May 3, 1972, supplements to the Draft Statement were issued which revised Chapter IV, Section C, Alternatives to the Proposed Action, and added Appendix G, Energy Alternatives, and Appendix H, Proposed Unit Plan Regulations. Notice of availability of the supplements was published in the Federal Register, May 3, 1972. The comment period on the original draft impact statement, the supplemental draft, and all the geothermal leasing, operating and unit regulations was extended to June 19, 1972.

Proposed leasing and operating regulations to implement the Geothermal Steam Act, Public Law 91-581, December 24, 1970, were published in the Federal Register on July 23, 1971; revised and published in the Federal Register on November 29, 1972; revised and published in the Federal Register on July 23, 1973; and corrected in the Federal Register on August 8, 1973. Proposed unit plan regulations were published in the Federal Register on May 3, 1972; revised and published in the Federal Register on November 29, 1972; revised and published in the Federal Register on July 23, 1973; and corrected in the Federal Register on August 8, 1973.

Public Hearings were held in Reno, Nevada, on November 9, 1971: Sacramento, California, on November 11, 1971; and Portland, Oregon, on November 12, 1971.

Written comments received in response to the Draft Statement and the proposed regulations are included in Volume IV of the Final Impact Statement. Reproductions of the written comments received in response to the proposed regulation revisions issued in 1973 and 1972 are included in Volume III, Appendix A-B and Appendix C-D of this Final Impact Statement.

Written comments and hearings material were systematically indexed by the Department of the Interior and the indexed material was made available to the specialists involved in the revision of the proposed regulations and in the preparation of the Final Impact Statement. These materials are available for public inspection in the Office of the Geothermal Coordinator, U.S. Department of the Interior, Washington, D.C., 20240.

Volume I of this statement primarily relates to the promulgation of leasing and operating regulations for implementation of the geothermal leasing program as authorized by the Geothermal Steam Act of 1970 (30 USC 1001-1025 (1970). The proposal is described in Chapter I. The national energy situation, geothermal energy resources and their potentials, description of resource development and production phases and a broad description of the environmental setting of the western states are included in Chapter II. The promulgation of leasing and operating regulations, the environmental impacts of the proposed action, mitigating measures, adverse impacts which cannot be avoided, the relationships between local short-term uses of man's environment and maintenance and enhancement of long-term productivity, and irreversible and irretrievable commitments of resources are discussed in detail in Chapter III. Chapter IV includes discussions of alternatives for timing of actions, environmental provisions of regulations, leasing options, Federal and private exploration and development and electrical energy sources.

Volume II primarily covers the environmental evaluations for the three areas in California being considered for leasing (Clear Lake-Geysers, Mono Lake-Long Valley and Imperial Valley). These statements generally follow the same format as used in Volume I but with particular emphasis on environmental considerations pertaining to each area. General environmental information as contained in Volume I is not repeated in the individual statements unless such is needed to facilitate the description of actions, mitigating measures and environmental impacts. Also included in this volume are summaries of comments and Departmental responses relative to the Draft Environmental Impact Statement, description of the consultation and coordination involved in the development of the proposal and the Draft Statement, and coordination in the review of the Draft Statement. Large scale maps of the three proposed lease areas are included in the pocket at the end of this volume.

Volume III consists of copies of the various Federal Register publications of proposed leasing and operating regulations and related information as follows:

Appendix A - July 23, 1973 Proposed Regulations for Leasing on Public, Acquired and Withdrawn Lands; Revision of Proposed Rule (Including corrections of August 8, 1973)

Appendix B - July 23, 1973 Proposed Regulations for Operations on Public, Acquired and Withdrawn Lands and Geothermal Resources Unit Plan Regulations

Appendix A-B-Copies of comments received in response to the July 23, 1973 proposed regulations

Appendix C - November 29, 1972 proposed leasing regulations and summary of documents and Departmental responses

Appendix D - November 29, 1972 proposed operating regulations and summary of comments and Departmental responses

Appendix C-D-Copies of comments received in response to the November 29, 1972 proposed regulations

Appendix E - July 23, 1971 proposed leasing and operating regulations and May 3, 1972 supplement

Appendix F - Summary of comments and Departmental responses to the July 23, 1971 and May 3, 1972 proposed regulations

Appendix G - Vapor Dominated Hydrothermal Systems Compared with Hot-Water Systems

Appendix H - Classification of Public Lands Valuable for Geothermal Steam and Associated Geothermal Resources

Volume IV includes copies of all comments received on the Draft Environmental Impact Statement and the proposed regulations of July 23, 1971 and May 3, 1972. Also included in this volume are copies of transcripts of the hearings held at Reno, Nevada on November 9, 1971; Sacramento, California on November 11, 1971; and Portland, Oregon on November 12, 1971.

AVAILABILITY OF FINAL ENVIRONMENTAL IMPACT STATEMENT

The four-volume set may be purchased as a complete set or as individual volumes from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402; the Map Information Office, Geological Survey, U.S. Department of the Interior, Washington, D.C. 20240; and the Bureau of Land Management State Offices at the following addresses:

555 Cordova Street
Anchorage, Alaska 99501

Room 3022, Federal Building
Phoenix, Arizona 85025

Federal Office Building
2800 Cottage Way
Sacramento, California 95825

Room 700, Colorado State Bank Building
1600 Broadway
Denver, Colorado 80202

Room 334, Federal Building
550 West Fort Street
Boise, Idaho 93724

Federal Building and U.S. Court House
316 North 26th Street
Billings, Montana 59101

Room 3008, Federal Building
300 Booth Street
Reno, Nevada 89502

U.S. Post Office and Federal Building
South Federal Place
Santa Fe, New Mexico 87501

729 N.E. Oregon Street
Portland, Oregon 97208

125 South State
Salt Lake City, Utah 84138

U.S. Post Office and Court House Building
2120 Capital Avenue
Cheyenne, Wyoming 82001

Inspection copies are available in the Library and the Office of the Geothermal Coordinator, U.S. Department of the Interior, Washington, D.C. 20240, and at depository libraries located throughout the Nation. The

Superintendent of Documents may be consulted for information regarding the location of such libraries. Inspection copies also are available in all of the Bureau of Land Management State Offices listed above and in the following Bureau of Land Management District Offices:

Fairbanks District Office
1028 Aurora Drive
P.O. Box 1150
Fairbanks, Alaska 99707

1414 University Avenue
Riverside, California 92502

Eastern States Land Office
7981 Eastern Avenue
Silver Spring, Maryland 20910

Outer Continental Shelf Office
Room T-9003, Federal Office Building
701 Loyola Avenue
New Orleans, Louisiana 70113

Room 311, U.S. Federal Building
800 Truxton Avenue
Bakersfield, California 93301

168 Washington Avenue
Ukiah, California 95482

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CHAPTER I

DESCRIPTION OF THE PROPOSAL

A. INTRODUCTION

The proposed action involves the leasing of federally owned geothermal resources for exploration and development pursuant to the Geothermal Steam Act of 1970. This environmental impact statement is issued in compliance with the requirements of Section 102(2)(c) of the National Environmental Policy Act of 1969 (42 U.S.C. 4332(2)(c)) with respect to the adoption of leasing, operating, and unit plan regulations pursuant to which the program would be administered, and the subsequent leasing of federally owned geothermal resources in three specific areas--Clear Lake-Geysers, Mono Lake-Long Valley, and Imperial Valley, all in California. Specific evaluations of the potential environmental impact of geothermal development and related activities for these three areas are included in this statement (Vol. II, Ch. V).

The development of geothermal steam and associated resources involves the harnessing of the natural heat energy sources in the earth for the generation of electric power and the production of commercially valuable by-products.

The use of geothermal steam as a source for electric energy is still, in large part, in the investigative stages. Commercial geothermal development in the United States to date is small, existing in only one area in California, and only there since about 1960. Developments in Italy have existed since about the turn of the century. Worldwide geothermal exploration and development in 1970 was limited to six fields (Table I-1) with a total present capacity of about 1,000 MW. Development of geothermal resources is similar to oil and gas production operations in that hot water and steam are produced from the earth through drilled holes. Operating plants for converting the steam to electrical energy consist of low pressure steam-turbine systems similar to those in use in the early 1920's. New technology should expand the use and adaptability of the resource beyond its current limitations to include more efficient conversion of heat energy stored in the geothermal fluids to electrical energy.

In meeting future energy demand, the Nation must use many available sources of energy--coal, gas, oil, hydroelectric, and nuclear among the more important--and no one source is an exclusive alternative to any or all of the other sources. In this context, geothermal energy hopefully would be a feasible means of supplementing other forms of electric power generation on the local scale. Under present technological and economic conditions, however, geothermal electric power cannot be expected to replace significant amounts of other forms of electric generation. Estimates of geothermal energy percentage of total national electrical power capacity by the year 2000 range from a low of 1 percent to a high of 20 percent, with most estimates in the low part of this range (see Ch. II-B for detail).

Table I-1. General characteristics of some geothermal electric power operations in 1970

GEOTHERMAL FLUID (S - STEAM; W - STEAM AND WATER)		1969 CAPACITY mw	NUMBER OF PLANTS	AREA (Approx.) mi²	PRODUCING WELLS: NUMBER	PRODUCING WELLS: AV. DEPTH ft.	PRODUCING WELLS: DIAM. IN PROD. ZONE in.	GEOLOGY OF PRODUCTIVE FM'S 1/	FURTHER DEVELOPMENT PLANS	REMARKS ON WATER
LARDERELLO ITALY	S	360	13	65	467	3300	13 3/8	Cavernous limestone and anhydrite, Mesozoic	Maintain operation in present field limits, but with 15% increase in plant productivity.	Condensate goes into natural drainage Until 1969 boron extracted for commercial use
WAIRAKEI NEW ZEALAND	W	160	1	1	61	2500	7 5/8	Rhyolitic pumice breccia and open-jointed welded tuff, m. Pleist, in region of volcanism and faulting	Maintain present level. Deep expl. neg.	Brine discharged in large river Land subsidence
THE GEYSERS UNITED STATES	S	83	2	1	17	2500-3000	8 5/8	Metamorphosed highly-fractured sandstone, shale, etc. of the Franciscan fm, Mesozoic	Expansion to 600 m w by 1975.	Boron and ammonia in condensate, 800 gpm injected into special well to avoid pollution of stream.
MATSUKAWA JAPAN	S	20	1	1/2	5	3600	7 5/8	Andesitic Volcanics, Pleist.	Expansion to 60 m w planned	Condensate discharged into natural drainage after experimentation on effects
OTAKE JAPAN	W	12	1	1/4	4	1000-3000	7 5/8	Andesitic Volcanics, Pleist.	In Aso Nat Park, special landscaping arrangements. Exponsion to 180 m w promising	To avoid pollution disposal pipeline to nearby hydropower reservoir Silica deposits restricted prod. 1968-9
CERRO PRIETO MEXICO	W		1	<1	15	4500	7 5/8	Highly-fractured sandstone and shale, San Jacinto Fault zone, Late Tertiary	75 m w plant under const, scheduled oper. in 1972, with future extension planned.	Brine to go to Gulf of Calif

1/ Formations.

"Worldwide Trends in Geothermal Resources Development-Progress and Problems" Denver, USBR, I E Klein, 1/71

The short-range prospects for geothermal power generation are most promising in California where favorable geologic conditions coincide with a heavy demand for electrical generating capacity. The present commercial development at The Geysers field in northern California compares favorably in cost with competing sources of power in that area and appears to have the added advantage of being less detrimental to the environment as compared to fossil or nuclear fueled steam-electric plants, which are the principal present alternatives. At The Geyers, geothermal steam-electric capacity as of early 1973 was 298MW. Present plans call for the addition of 110 MW in both 1973 and 1974 to reach a total installed capacity of 518 MW. Beyond 1974, the Pacific Gas and Electric Company (PG&E) tentatively has scheduled installation of at least 100 MW of new capacity per year, depending upon availability of steam. Estimated ultimate capacity of The Geysers field is 1,000 to 2,000 MW, but this remains to be proven. Thus, in the PG&E system, it is clear that development of The Geysers is a viable alternative to additional generating capacity using fossil or nuclear fuels.

Elsewhere in California, favorable areas for prospecting are the Imperial Valley area and the Mono Lake-Long Valley area. Test drilling in both areas suggests promising prospects for commercial power development. In both areas the handling and disposal of large volumes of water may pose significant technical, economic, and environmental problems that must be resolved before large-scale power development could proceed. The feasibility of commercial power generation in the United States still remains to be demonstrated except at The Geysers.

B. LEASING OF GEOTHERMAL RESOURCES

Proposed leasing and operating regulations to implement the Geothermal Steam Act were published in the Federal Register on July 23, 1971, revised and published in the Federal Register on November 29, 1972, and further revised and published in the Federal Register on July 23, 1973, and corrected in the Federal Register on August 8, 1973. Proposed unit plan regulations were published in the Federal Register on May 3, 1972, revised and published in the Federal Register on November 29, 1972, and further revised and published in the Federal Register on July 23, 1973 (copies are included in Appendices A through E). These regulations provide the framework for leasing, exploration, development, and utilization of geothermal resources on public lands, consistent with multiple-use management objectives.

Some 1.8 million acres have been identified as of August 1972 to have significant potential for geothermal resource development and have accordingly been classified as Known Geothermal Resources Areas (KGRA's) (Figure I-1 and Appendix H). Announcements of these classifications were published in the Federal Register (36 F.R. 5626, 5627, as corrected, 36 F.R. 6118; 36 F.R. 6441, 6442; 36 F.R. 7319, 7320, as corrected, 36 F.R. 7759 and 36 F.R. 19409). Any additional classification will be published in the Federal Register as soon as possible after it has been

Figure I-1. Known geothermal resources areas

Detailed land descriptions of these areas have been published in the Federal Register, v. 36, p. 5626, March 25, 1971; v. 36, p. 6118, April 2, 1971; v. 36, p. 6441, April 3, 1971; v. 36, p. 7319, April 17, 1971; v. 36, p. 7759, April 24, 1971 and v. 36, p. 19409, October 5, 1971.

No. on Figure 1A, 1B, or 1C	Name
ALASKA	
1	Pilgrim Springs
2	Geyser Spring Basin and Okmok Caldera
CALIFORNIA	
1	The Geysers
2	Salton Sea
3	Mono-Long Valley
4	Calistoga
5	Lake City
6	Wendel-Amedee
7	Coso Hot Springs
8	Lassen
9	Glass Mountain
10	Sespe Hot Springs
11	Heber
12	Brawley
13	Dunes
14	Glamis
15	East Mesa
IDAHO	
1	Yellowstone
2	Frazier
MONTANA	
1	Yellowstone

No. on Figure 1A, 1B, or 1C	Name
NEVADA	
1	Beowawe
2	Fly Ranch
3	Leach Hot Springs
4	Steamboat Springs
5	Brady Hot Springs
6	Stillwater-Soda Lake
7	Darrough Hot Springs
8	Gerlach
9	Moana Springs
10	Double Hot Springs
11	Wabuska
12	Monte Neva
13	Elko Hot Springs
NEW MEXICO	
1	Baca Location No. 1
OREGON	
1	Breitenbush Hot Springs
2	Crump Geyser
3	Vale Hot Springs
4	Mount Hood
5	Lakeview
6	Carey Hot Springs
7	Klamath Falls
UTAH	
1	Crater Springs
2	Roosevelt
WASHINGTON	
1	Mount St. Helens

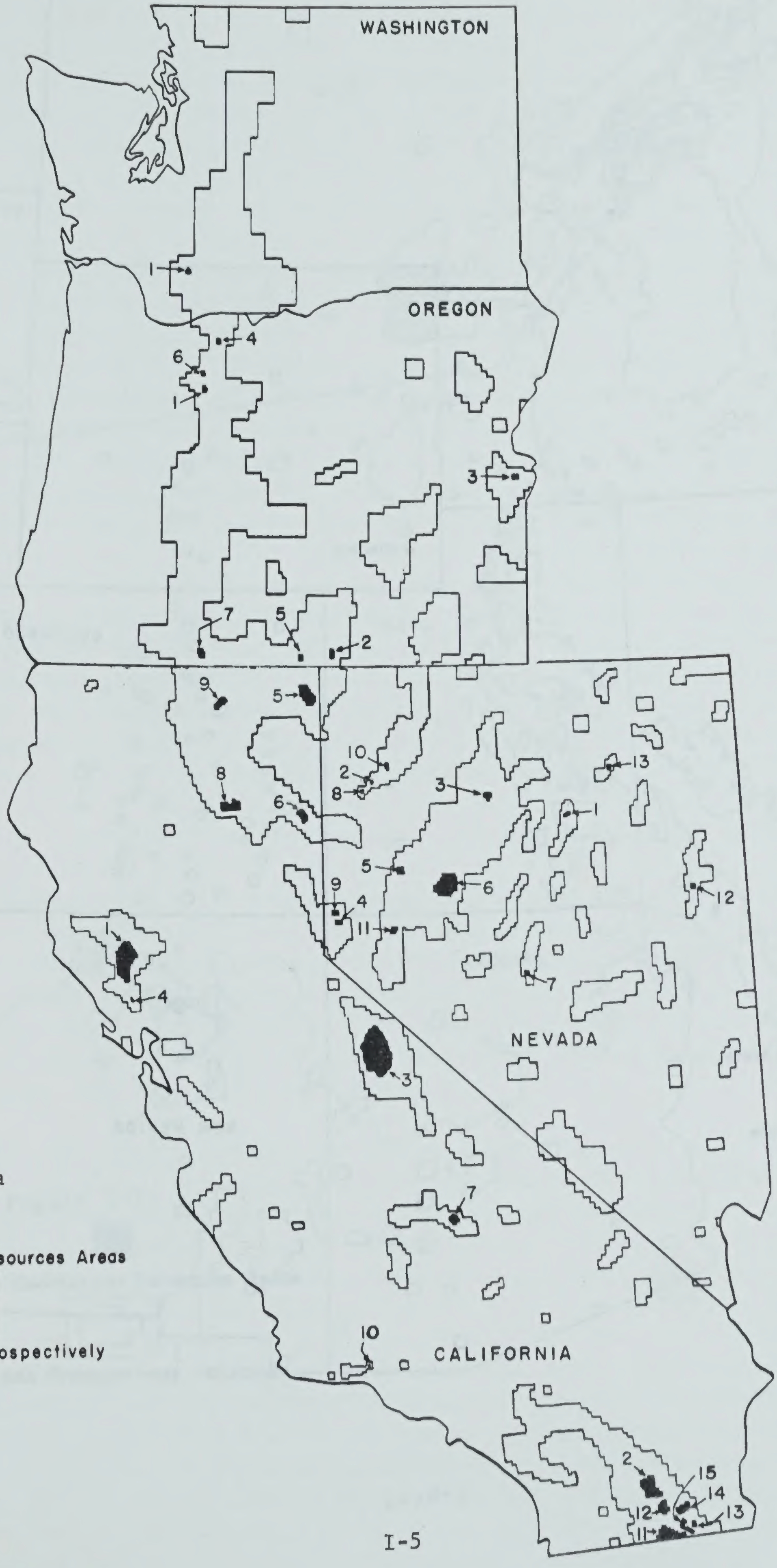
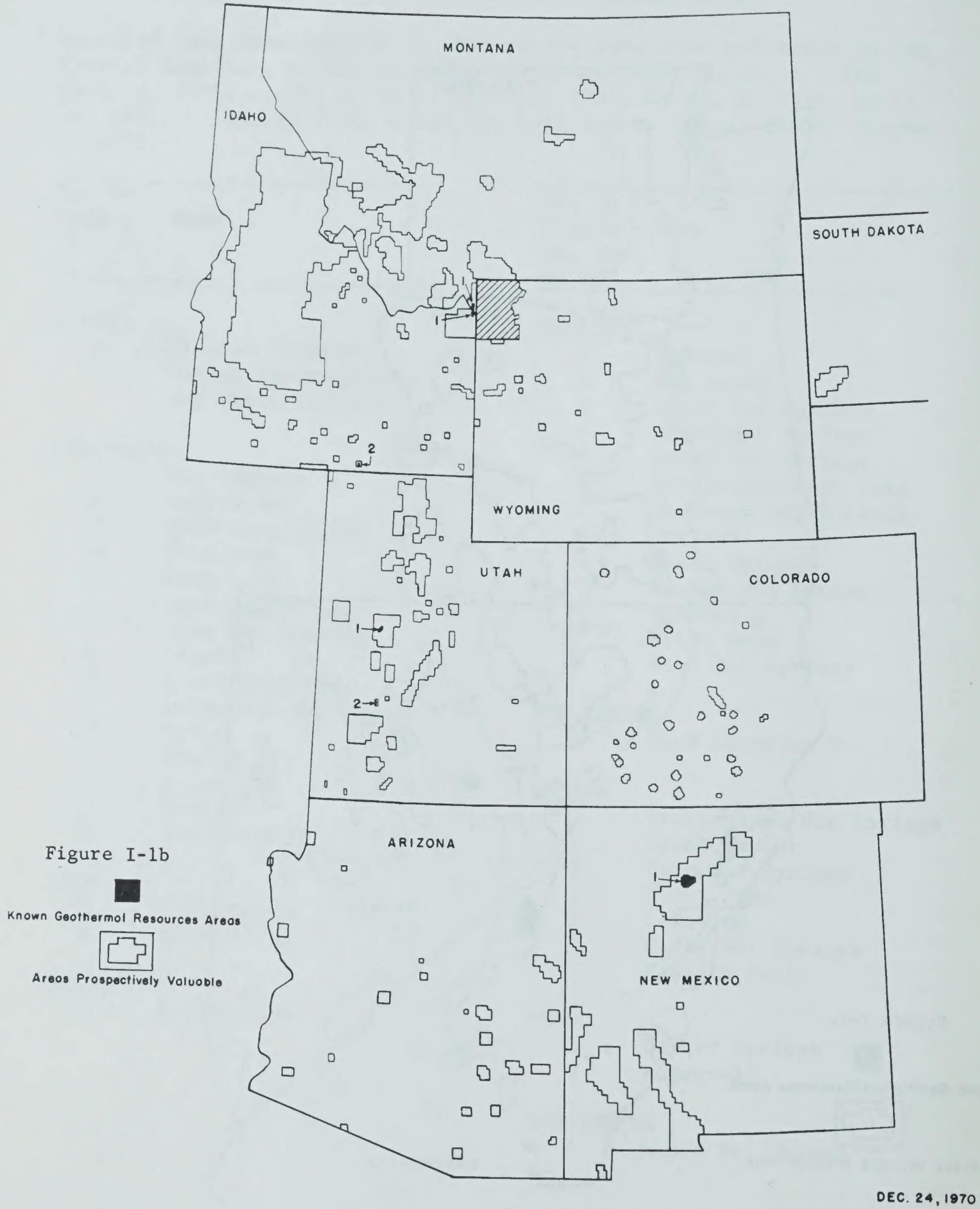


Figure I-1a

Known Geothermal Resources Areas

Areas Valuable Prospectively

INT: 1081-72
AUG. 21, 1972



MONTANA
IDAHO
SOUTH DAKOTA
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
1
2
Known Geothermal Resources Areas
Areas Prospectively Valuable
DEC. 24, 1970

Figure I-1b

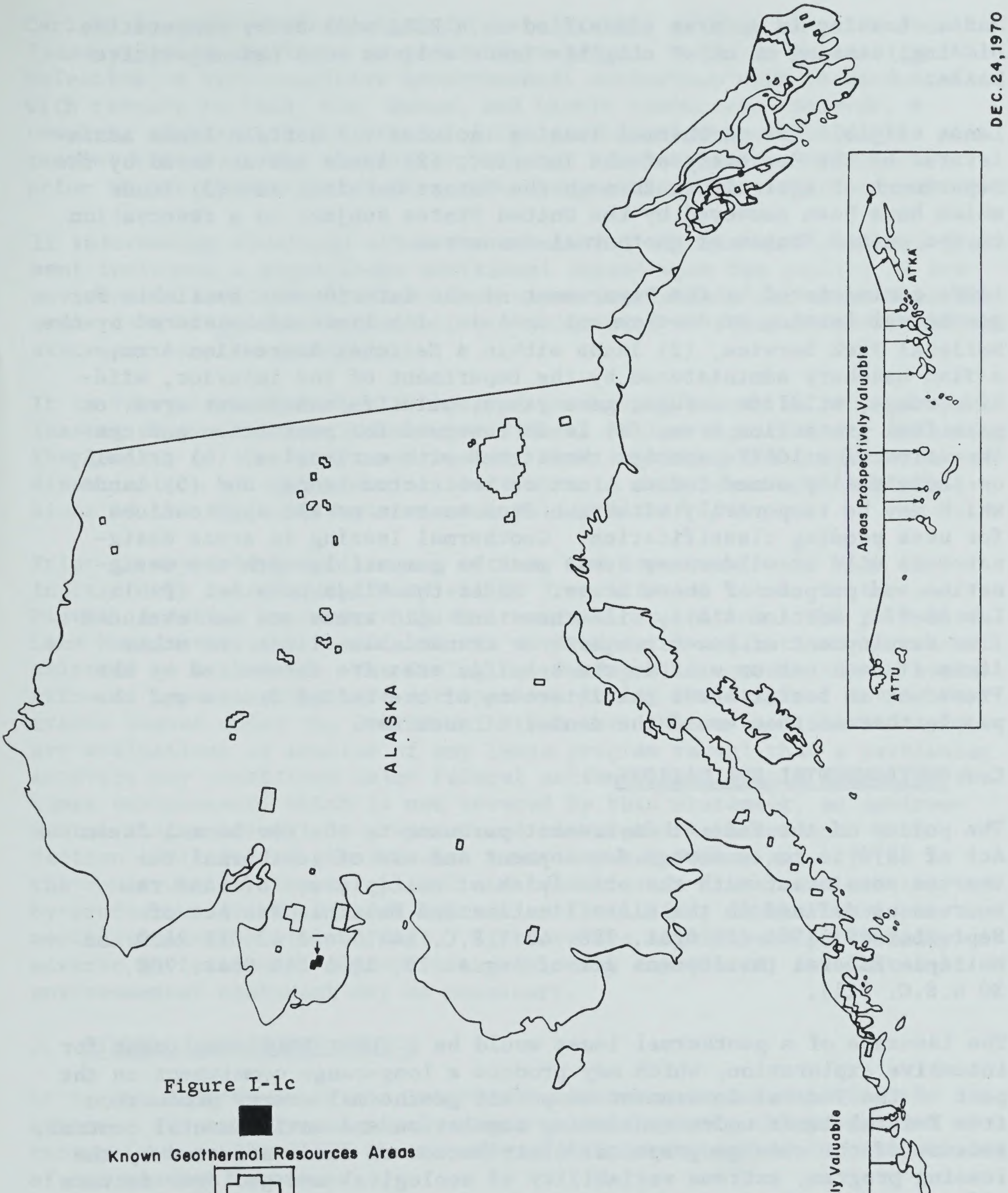

DEC. 24,1970
ALASKA
Areas Prospectively Valuable
ATTU
ATKA
Areas Prospectively Valuable
UMNAK
IUKTA
2
Known Geothermal Resources Areas
Areas Prospectively Valuable

Figure I-1c

made. Leasing in an area classified as a KGRA will be by competitive bidding; leasing on other eligible lands will be on a noncompetitive basis.

Lands eligible for geothermal leasing include: (1) certain lands administered by the Secretary of the Interior, (2) lands administered by the Department of Agriculture through the Forest Service, and (3) lands which have been conveyed by the United States subject to a reservation to the United States of geothermal resources.

Lands administered by the Department of the Interior not available for geothermal leasing or development include: (1) lands administered by the National Park Service, (2) lands within a National Recreation Area, a fish hatchery administered by the Department of the Interior, wildlife range, wildlife refuge, game range, wildlife management area, or waterfowl protection area, (3) lands reserved for protection and conservation of wildlife species threatened with extinction, (4) tribally or individually owned Indian trust or restricted lands, and (5) lands which may be temporarily withdrawn from certain or all applications for uses pending classification. Geothermal leasing in areas designated as wild or wilderness areas must be compatible with the designation and purpose of these areas. Under the Wilderness Act (Public Law 88-577, Section 4(4)), wilderness and wild areas are not excluded from development of power projects or transmission lines and other items if such use or uses in the specific area are determined by the President to better serve the interests of the United States and the people thereof than would the denial of such use.

C. ENVIRONMENTAL EVALUATIONS

The policy of the Federal Government pursuant to the Geothermal Steam Act of 1970 is to encourage development and use of geothermal resources consistent with the principles of multiple use of land resources as defined in the Classification and Multiple Use Act of September 19, 1964 (78 Stat. 986, 43 Y.S.C. 1411) and 43 CFR 2420 and Multiple Mineral Development Act of August 13, 1954 (68 Stat. 708, 30 U.S.C. 521).

The issuance of a geothermal lease would be a short-term commitment for intensive exploration, which may produce a long-range commitment on the part of the Federal Government to permit geothermal energy production from Federal lands under continuing regulation and environmental control. Because of the wide geographical distribution of lands affected by the leasing program, extreme variability of ecological and geologic factors affecting these lands, and limited experience in geothermal resource development, it is not possible to include in this statement details for all potential individual lease areas and the specific environmental impacts that might pertain to each area. Specific details will be identified, evaluated, and described in the environmental analysis record prepared for each lease area prior to any leasing action.

Certain specific environmental data are lacking at this time for some lease sites in the three proposed lease areas. Prior to lease-site selection, a site sensitive environmental evaluation will be conducted with respect to land, air, water, and biotic resources. However, a complete analysis of the nature of the geothermal resources and its potential effect on the environment may not be possible in most cases prior to the completion of the production testing phase of lease operations.

If information developed after the submission of this environmental statement indicates a significant additional impact upon the quality of the environment could result from lease operations within the three specific areas covered by this statement, a supplemental or separate environmental statement may be necessary.

It is recognized that the issuance of geothermal leases in other proposed leasing areas may constitute major Federal action significantly affecting the quality of the human environment, thus requiring the preparation and dissemination of environmental statements in accordance with the provisions of the National Environmental Policy Act of 1969.

Prior to any subsequent leasing action, the Department will seek the input of the interdisciplinary skills from affected local, State, and Federal agencies in conducting environmental evaluation. The Bureau of Land Management will coordinate the environmental evaluations on tracts selected to be leased. The Geological Survey will coordinate the evaluation of impacts which were not apparent during the original review on tracts leased under the Geothermal Steam Act. Where the interdisciplinary evaluations or studies of any lease program reveal that a particular activity may constitute major Federal action significantly affecting the human environment, which is not covered by this statement, an environmental statement will be prepared and circulated in accordance with Section 102(2)(c) of the National Environmental Policy Act. Prior to the construction of power plants and transmission lines, and possibly of by-product water and mineral extraction facilities, further environmental evaluation will be made. If there are significant potentially adverse environmental impacts not previously considered, an additional environmental statement may be necessary.

D. MINERAL MANAGEMENT POLICY

It is the Department of the Interior's mineral management policy to assure: (1) orderly and timely resource development, (2) protection of the environment, and (3) the receipt of fair market value for disposition of the mineral resources.

1. Orderly and timely development includes the responsibilities to: foster, promote, and encourage the exploration for and the production of the mineral deposits from the Federal lands; promote competition; encourage the active development of the mineral deposits in the Federal lands in a manner compatible with the use of the same lands for other purposes; assure that mineral developers receive the acreage necessary for economic plant investment, development, and production; encourage

the maximum ultimate recovery of the mineral deposit; prevent waste; promote conservation of the mineral resources; and assure adequate minimum production and diligent development requirements for leased mineral deposits.

2. Protection of the environment includes the responsibilities to: assure that mineral exploration and production be conducted with the maximum protection of the environment; assure the rehabilitation of the disturbed lands; assure that precautions are taken to protect public health and safety; and assure full compliance with the spirit and objectives of the National Environmental Policy Act of 1969, other Federal environmental legislation, and supporting Executive Orders and regulations.

3. Receipt of fair market value includes the responsibility to assure the public a fair market value return for the use of public lands and the disposition of its mineral resources.

E. ADMINISTRATIVE ROLES AND PROCEDURES

Management responsibilities for the public lands and their natural resources are shared by the land management agencies and the Geological Survey. Secretarial Order No. 2948, dated October 6, 1972, sets forth in the following manner the division of responsibility between the Bureau of Land Management and the Geological Survey for the administration and management procedures for all departmental onshore mineral leasing and operating activities, including geothermal resources. The Order provides:

"The BLM exercises at the Bureau level the Secretary's discretionary authority to determine whether or not leases, permits, and licenses are to be issued. The Bureau of Land Management is responsible for issuing mineral leases, permits, and licenses, and is the office of record in mineral leasing matters. The Geological Survey is responsible for all geologic, engineering, and economic value determinations for the Department's mineral management program. These determinations include: the mineral characteristics of lease and permit areas; parcelling; amounts of bonds; royalties; unit values; rentals; and minimum production requirements; and all other terms and conditions relating to mineral operations under leases and permits. Geological Survey exercises the Secretary's delegated authority regarding operations conducted within the area of operation by permittees, lessees, and licensees and determines the actions to be taken by them from the standpoint of the development, conservation, and management of mineral resources under the jurisdiction of the Department. GS will refer to BLM any instances of noncompliance with lease terms requiring cancellation action, and BLM will initiate the necessary action.

"For the purpose of this Order, the area of operation is defined as that area of the present and planned mine, oil and gas field, or geothermal resource field exploratory, development, and production operations, as presented in an approved exploration or mining plan, drilling permit,

oil, gas, or geothermal field development plan, or plan for the abandonment of wells or operations. The area of operation may cover a fraction of a lease or permit area, or it may cover several lease or permit areas. It encompasses the general area needed for storage piles, spoils piles, tailings ponds, on-project mill sites, flow lines, separators, surge tanks, on-project truck or rail-loading stations, drill pads, mud pits, workshops, compressors, generators, on-project power plants, and other such facilities used for on-project mine, oil and gas field, or geothermal resource field exploratory, development, and production operations."

1. Environmental Protection.

"The Bureau of Land Management, in cooperation with the Geological Survey, formulates the general requirements to be incorporated in leases, permits, and licenses for the protection of the surface and non-mineral resources and for reclamation. The Geological Survey, before approving exploration and mining plans, drilling permits, oil, gas, or geothermal field development plans, or plans for the abandonment of wells or operations, consults with the Bureau of Land Management on the adequacy of the surface use, environmental protection, and reclamation aspects of the plans and will not grant approval if inconsistent with the BLM's recommendations without further discussions with BLM. If differences remain after these further discussions, the resolution is made by the Assistant Secretary--Energy and Mineral Resources and the Assistant Secretary--Land and Water Resources. If required, the Under Secretary resolves any remaining differences. The BLM is responsible for compliance examinations of environmental protection requirements outside the operating area and for reporting infractions to the GS for discussions with, or orders to, the permittee, lessee, or licensee. GS examines operations to ensure compliance with environmental protection and rehabilitation requirements inside the operating area. With respect to approval of access roads, pipelines, utility routes and other surface uses outside the operating area, the Bureau of Land Management has the primary responsibility but obtains the recommendations of the Geological Survey before taking final action. Orders to operators for any remedial action is the responsibility of the Geological Survey."

2. Expertise

"The Geological Survey is responsible for maintaining engineering, geologic, geophysical, economic, and other technical expertise needed by the Department to assure compliance with applicable laws, operating regulations, and the objectives of the Department's mineral management program. The Bureau of Land Management is responsible for maintaining expertise needed by the Department for action on applications filed with BLM under the mineral leasing laws to assure compliance with applicable laws, leasing regulations, and the objectives of the Department's mineral management program."

3. Contacts with Applicants

"(1) Prior to the issuance of mineral leases, permits, and licenses, the Bureau of Land Management will represent the Secretary in dealing with applicants.

"(2) After issuance and during the exploration, development, and production phases of leases, permits, and licenses, and until a lease, permit, or license has terminated (at which time management is the sole responsibility of BLM) the Geological Survey is the sole representative of the Secretary in all matters relating to the supervision of operations."

4. Issuance of Mineral Leases, Permits, and Licenses

"(a) Applications - Prior to the issuance of mineral prospecting permits, leases, or licenses, the Bureau of Land Management refers all applications for such permits, leases, or licenses to the Geological Survey for a report as outlined in (b) below.

"(1) The Geological Survey is responsible for determining, under the mineral leasing laws and regulations, if sufficient information is known about a mineral deposit to warrant offering the deposit for lease by competitive sale and to notify the Bureau of Land Management of its determination. If the Geological Survey finds that sufficient information is not available to warrant competitive leasing, it notifies the Bureau of Land Management of its conclusions so that the Bureau of Land Management may issue a prospecting permit or noncompetitive lease, as appropriate. The Geological Survey establishes prospecting requirements for prospecting permits. When lands are to be leased, the Geological Survey determines and reports, as appropriate, on: the mineral characteristics of lease and permit areas; parcelling; amounts of bonds; royalties; unit values; rentals; mineral resource evaluations; reserves; investments; diligent development and minimum production requirements; and all other terms and conditions pertaining to lease operations, including environmental and surface rehabilitation stipulations relating to mineral exploration and extraction. With respect to applications for licenses, the Geological Survey determines and reports as to whether the license may be issued.

"(2) The Geological Survey is responsible for determining whether a prospecting permittee has demonstrated that the lands contain a mineral deposit having the characteristics required by law and regulations to qualify for a preference right lease and to notify the Bureau of Land Management.

"(3) The Bureau of Land Management refers to the Geological Survey all other type applications received which, if approved, may affect operations on existing permits, leases, or licenses.

"(4) The Bureau of Land Management notifies the Geological Survey of known oil, gas, and geothermal resource geophysical exploration activity, including the area involved, the type of survey employed, and the name of the operator.

"(5) All applications for noncompetitive oil and gas, mineral, and geothermal resource leases filed with the Bureau of Land Management will, prior to issuance of a lease, be referred to the Geological Survey for a determination as to whether the lands are within a known geologic structure (KGS), a known geothermal resource area (KGRA), or

a known leasing area (KLA).

"(b) Mineral Resource Evaluation Report - GS is responsible for submitting a report of its findings, mineral resource evaluations, and resultant recommendations to the BLM, together with a summary explanation of how the resource evaluations were developed from geophysical, geologic, economic, and engineering data available at the time of the evaluation. The BLM reviews these findings and recommendations in light of multiple-use management requirements and will not issue leases or permits inconsistent with the findings and recommendations without further discussion with GS. If differences remain after further discussion, the resolution is made by the Assistant Secretary--Mineral Resources and the Assistant Secretary--Public Land Management.* If required, the Under Secretary resolves any remaining differences.

"(c) Competitive Lease Sales - The Bureau of Land Management advertises and conducts competitive lease sales. The Geological Survey's resource evaluations will be used and the Geological Survey will have representatives at the sale and renders a post-sale recommendation to BLM regarding acceptance or rejection of the bids, which must be confirmed in writing.

"(d) Files and Records - BLM maintains the official application, permit, and lease case files and forwards to the Geological Survey a copy of each permit, lease, and license, together with copies of relevant correspondence thereafter conducted by the Bureau. The GS forwards to the BLM copies of mining and exploration plan applications, drilling permit applications, and relevant items submitted by the applicants directly to the GS, except confidential proprietary information cited under paragraph (e) below.

"(e) Security of Information - The Geological Survey is responsible for receiving and protecting for the confidential use of the Federal Government all proprietary geological, geophysical, engineering, economic, statistical, or other information, mineral resource data, and well logs required to be submitted under Title 30 CFR, Parts 200, 211, 216, 221, 231, 270, and related regulations. The Survey Office receiving such information is designated the Office of Control for those data. Authorized officials of BLM or other surface-managing agencies having a need to see such information will normally make appropriate arrangements to visit the Office of Control for access to such data and for technical advice based on it pertinent to their management responsibilities."

5. Mineral Reports

"The Geological Survey is responsible for preparing and submitting to the Bureau of Land Management mineral classification and evaluation reports with respect to the leasable mineral value of lands within proposed exchanges, withdrawals, sales, land entries, or other disposals and all other land transactions. The Geological Survey, upon request, also prepares and furnishes mineral reports and other information to the Bureau of Land Management needed for its use in longrange multiple-use planning or inventory of the public lands."

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* Now Assistant Secretary--Land and Water Resources.

6. General Relationships

"Such additional references, reports, interchange of information, and advice shall be made by or between the Bureau of Land Management and Geological Survey as may be necessary to perpetuate or improve current practice and provide effective administration of the mineral leasing laws.

"The Bureau of Land Management and the Geological Survey must submit to each other for review and recommendations any proposed changes in standard lease terms, regulations, instructions, or other changes that would affect each agency's management responsibilities."

7. Forest Service

The Forest Service is charged with the responsibility of full management of all lands within the national forest system. It is proposed that this agency will follow the procedure outlined below in geothermal leasing situations:

a. A plan of operation is required to be submitted by the applicant.

b. An on-site field examination is conducted with the Geological Survey and applicant. At this time a determination is made of exact requirements as to surface improvements and the operating area is delineated.

c. Full responsibility for management within the operating area is assumed by Geological Survey. However, the Forest Service acts as the observor and may make GS aware of any unauthorized operations.

d. The Forest Service retains full management prerogatives within the lease that is outside of the area of operations.

e. Surface and resources protection stipulations are prepared in cooperation with the Geological Survey.

CHAPTER II

THE ENERGY AND ENVIRONMENTAL SETTING

A. THE NATIONAL ENERGY SITUATION

On April 18, 1973, the President forwarded to the Congress his second Energy Message. His message presented a comprehensive program to provide for meeting current and future energy needs, with particular emphasis on increased production of fuels from domestic sources. In the introduction to this message, he summarized the energy situation as follows:

> "At home and abroad, America is in a time of transition. Old problems are yielding to new initiatives, but in their place new problems are arising which once again challenge our ingenuity and require vigorous action. Nowhere is this more clearly true than in the field of energy.
>
> "As America has become more prosperous and more heavily industrialized, our demands for energy have soared. Today, with 6 percent of the world's population, we consume almost a third of all the energy used in the world. Our energy demands have grown so rapidly that they now outstrip our available supplies, and at our present rate of growth, our energy needs a dozen years from now will be nearly double what they were in 1970.
>
> "In the years immediately ahead, we must face up to the possibility of occasional energy shortages and some increase in energy prices.
>
> "Clearly, we are facing a vitally important energy challenge. If present trends continue unchecked, we could face a genuine energy crisis. But that crisis can and should be averted, for we have the capacity and the resources to meet our energy needs if only we take the proper steps -- and take them now.
>
> "More than half the world's total reserves of coal are located within the United States. This resource alone would be enough to provide for our energy needs for well over a century. We have potential resources of billions of barrels of recoverable oil, similar quantities of shale oil and more than 2,000 trillion cubic feet of natural gas. Properly managed, and with more attention on the part of consumers to the conservation of energy, these supplies can last for as long as our economy depends on conventional fuels.
>
> "In addition to natural fuels, we can draw upon hydroelectric plants and increasing numbers of nuclear powered facilities.

Moreover, long before our present energy sources are exhausted, America's vast capabilities in research and development can provide us with new, clean and virtually unlimited sources of power.

"Thus we should not be misled into pessimistic predictions of an energy disaster, But neither should we be lulled into a false sense of security. We must examine our circumstances realistically, carefully weigh the alternatives -- and then move forward decisively.

WEIGHING THE ALTERNATIVES

"Over 90 percent of the energy we consume today in the United States comes from three sources: natural gas, coal and petroleum. Each source presents us with a different set of problems.

"Natural gas is our cleanest fuel and is most preferred in order to protect our environment, but ill-considered regulations of natural gas prices by the Federal Government have produced a serious and increasing scarcity of this fuel.

"We have vast quantities of coal, but the extraction and use of coal have presented such persistent environmental problems that, today, less than 20 percent of our energy needs are met by coal and the health of the entire coal industry is seriously threatened.

"Our third conventional resource is oil, but domestic production of available oil is no longer able to keep pace with demands.

"In determining how we should expand and develop these resources, along with others such as nuclear power, we must take into account not only our economic goals, but also our environmental goals and our national security goals. Each of these areas is profoundly affected by our decisions concerning energy.

"If we are to maintain the vigor of our economy, the health of our environment, and the security of our energy resources, it is essential that we strike the right balance among these priorities.

"The choices are difficult, but we cannot refuse to act because of this. We cannot stand still simply because it is difficult to go forward. That is the one choice Americans must never make.

"The energy challenge is one of the great opportunities of our time. We have already begun to meet that challenge, and realize its opportunities."

Department of the Interior forecasts of United States energy supply and consumption to the end of the present century (Dupree and West, December 1972) indicate that gross energy consumption (including the conversion of primary energy forms to secondary forms such as electricity and synthetic gas) is expected to grow at an average rate of 3.6 percent annually over the period increasing from 69 quadrillion Btu to 192 quadrillion Btu in year 2000.

Natural gas usage will increase from the 1971 figure of 22 trillion cubic feet to 33 trillion cubic feet by the end of the Century. Its share of the market will shrink from 33 percent to 18 percent. In addition, some 5 1/2 trillion cubic feet of gas are expected to be manufactured from more than 300 million tons of coal and 100 million barrels of oil in the Year 2000. This reflects a conversion efficiency of 72 percent, and would supply approximately 14 percent of total gaseous fuels in that year.

Annual petroleum usage is expected to increase from 5 1/2 billion barrels to 13 billion barrels over the 29-year period, including 100 million barrels in Year 2000 used to manufacture gas. Oil's share of primary energy input would decline from 1971's 44 percent to 37 percent in the terminal year.

Coal usage is estimated to grow slowly to 1980 and more rapidly thereafter as measures are found to make it environmentally acceptable.

Total consumption in the year 2000, including coal used for gasification, is anticipated to exceed 1,300 million tons or 2½ times the total burned in 1971.

Use of both coal and nuclear power will expand due to the extensive increase in use of electricity that is foreseen. Although population is forecast to grow only at a 1 percent annual rate, per capita usage of electricity is estimated to more than quadruple, resulting in a total increase in power consumption of approximately 500 percent. The contribution of nuclear plants to total electricity generation is expected to rise from 2 percent in 1971 to slightly more than half in year 2000 (Dupree and West, 1972).

The following sections highlight major considerations relative to the projection of future energy consumption, environmental considerations and supply sources.

1. <u>Total Energy Consumption</u>

Projection of total energy consumption, particularly for the long term, is extremely tenuous. Professor Richard L. Gordon, in a report prepared for the trans-Alaska pipeline investigation (Gordon, 1971), and a report for the Committee on Interior and Insular Affairs (U.S. Senate, 1971), analyze a number of relevant factors and list various forecasts. Since those reports, additional forecasts have become available, including a new Department of the Interior forecast (Dupree and West, 1972).

Those reports prepared since 1969 are listed in Table II-1. The projections are subject to wide variation as indicated in Figure II-1, in which the various estimates have been plotted. Except in rare instances, however, recent forecasts agree that energy consumption will increase between 4 and 5 percent per year at least through 1985. Resource availability, cost, and environmental concerns may modify later growth rates.

Projections of the mix of energy sources within the total consumption vary more widely than do those of total consumption. Table II-2 shows recent projections of domestic consumption mix for 1980 and 1985. Nuclear power will become increasingly important. Most projections suggest declining market shares for gas and hydroelectric power. There is considerable disagreement concerning the future roles of coal and oil, stemming primarily from uncertainty with regard to supplies and the impact of air quality and other environmental requirements.

The actual future mix of energy sources will depend on a number of decisions on matters of energy and environmental policy which will be made in the next few years. The energy consumption projections discussed above make a variety of assumptions, either explicit or implicit, about the outcomes of current policy debates. For example, the National Petroleum Council's four cases assume four different mixes of policy and success of exploratory effort.

2. Environmental Considerations

The Nation has become concerned over the quality of its environment. Responses to this concern have taken the form of legislation and regulatory action to minimize air and water pollution and scarring of the landscape. Perhaps the environmental effect most obvious to the largest number of Americans is the air pollution in major urban areas; the Clean Air Amendments of 1970 (P.L. 91-190, 42 U.S.C. 1851 et. seq., 49 U.S.C. 1421, 1430) required establishment of air quality standards and of plans by each state to achieve implementation of those standards by 1975. Many of these state implementation plans (SIPs) will require alteration of energy consumption patterns.

In view of the outcome of recent litigation over state implementation plans, it is clear that air quality considerations will be an important determinant of energy consumption patterns for the foreseeable future. From the standpoint of air quality at the point of combustion, natural gas has been restrained largely by the market disequilibrium. Other environmental effects, notably impact on land values and water quality during extraction and transportation, may limit the roles of coal and oil. While nuclear power offers the potential of electrical energy with relatively small volumes of air emissions, considerations of thermal water pollution and public safety, as well as delays in engineering and construction, have limited that option.

Table II - 1.
RECENT PROJECTIONS OF UNITED STATES ENERGY CONSUMPTION 1/*
Quadrillion (10^{15}) BTU Per Year**

Date	Source	Ref. 4/	1975	1980	1985	1990	2000	Gordon 2/	Senate 3/
4-70	SRI	(a)	5/	5/	-	-	-	-	X
4-70	EBASCO	(b)	83.1	100.0	120.0	-	-	-	X
10-70	Morrison	(c)	-	95.1	-	134.7	168.6	-	X
?-70	SO (NJ) 6/	(d)	-	106.0	131.0	-	-	X	-
1-71	USDI	(e)							
	Low		-	98.9	120.8	-	-	X	-
	Medium		-	103.5	127.7	-	-	X	-
	High		-	108.8	133.1	-	-	X	-
2-71	Darnstadter 11/	(f)	-	95.1 11/	-	134.7 11/	190.0	-	X
6?-71	Oil Co.#4 7/	(g)	-	105.3	-	-	-	X	-
6-71	Oil Co.#5 7/	(g)	88.0	-	134.0	-	-	X	-
6-71	Oil Co.#6 7/	(g)	83.6	102.7	129.1	-	-	X	-
6-71	Oil Co.#7 7/	(g)	-	100.9	-	-	-	X	-
6-71	USDI	(h)	88.6	-	133.4	-	191.6	X	-
7-71	NPC	(i)	83.5	102.6	124.9	-	-	X	X
9-71	Starr	(j)	81	-	-	-	160.0	-	-
?-71	USBM	(k)							
	Low		-	-	-	-	166.0	X	X
	High		-	-	-	-	239.1	X	X
?-71	FPC	(l)	-	105.0	-	143.0	-	-	X
?-71	Gambs	(m)	-	110.0	-	-	-	X	-
?-71	Marathon	(d)	-	101.6	-	-	-	X	-
?-71	Schurr	(n)	-	90.9	-	-	-	X	-
?-71	SO (NJ) 6/	(d)	-	106.0	131.0	-	-	X	-
?-71	Steele	(o)	-	105.3	128.5	-	-	X	-
1-72	USDI	(h)	88.6 8/	-	133.4 8/	-	191.6 8/	-	-
2-72	Morrison	(p)	-	-	-	-	169 8/	-	-
6-72	Chase	(f)	-	-	130.2 9/	-	-	-	-
11-72	USDI 10/								
12-72	NPC	(t)	83.5 8/	102.6 8/	124.9 8/	-	-	-	-
	Compound growth relative to 1971 actual consumption of 69.0 QBtu, at alternative rates of:								
	3%		77.7	90.0	104.0	121.0	162.6		
	3 1/2%		79.2	94.1	111.7	137.7	187.1		
	4 %		80.7	98.2	119.5	145.4	215.2		
	4 1/2%		82.3	102.6	127.8	159.3	247.3		
	5%		83.9	107.0	136.6	174.4	284.0		

* Notes appear on the following page.

** Btu (British thermal unit) is a standard measure of energy (amount of heat necessary to raise the temperature of 1 pound of water 1° F.

NOTES TO TABLE II - 1

1/ Total gross energy inputs in the United States in 1971 were 69.010 quadrillion BTU(reference (r)).*

2/ Included in the review in Gordon (1971).

3/ Included in the review in U.S. Senate (1972).

4/ References are listed below.

5/ Totals not comparable, since SRI excludes transportation uses.

6/ Standard Oil of New Jersey (now Exxon).

7/ Oil companies so designated to maintain confidentiality and distinguish among estimates.

8/ Republication of earlier estimate.

9/ Calculated from 63,715,000 bbl./day oil equivalent, using conversion factor of 5,600,000 BTU/bbl. (Chase gives 1970 consumption of 32,980,000 b/d ; reference (r) gives 67.444 Q BTU, implying a conversion rate of 67.444×10^{15} BTU /(365 days x 32.98 x 10^6 b/d) = 5602731 BTU/bbl.)

10/ This forecast is designed to become the current set of Interior Department projections.

11/ The Darnstadter projection, as published in U.S. Senate (1972) apparently differs from Morrison only in the year 2000.

REFERENCES TO TABLE II - 1

(a) SRI-70: Requirements for southern Louisiana natural gas through 1980: Exhibit in FPC docket No. AR69-1, Stanford Research Institute, April 1970.

(b) EBASCO-70: Energy consumption and supply trends chart book, April 1970: EBASCO Services Inc.

(c) Morrison-70: "Energy Resources and National Strength" by Warren E. Morrison: Auditorium presentation, Industrial College of the Armed Forces, Washington, D.C., October 6, 1970 (transcript of lecture and statistical appendix).

*Preliminary estimates indicate that U.S. energy consumption in 1972 was 72.091 QBtu (USBM, 1973).

(d) Cited in Gordon, Richard L. (Professor of Mineral Economics, Pennsylvania State University), "Future Demand for Petroleum in the United States. A Review of Forecasts," July 15, 1971. Included as appendix L, part 1 in (U.S. D.I., 1971).

(e) U.S. Department of the Interior Draft Environmental Impact Statement for the Trans-Alaska Pipeline, January, 1971.

(f) Darnstadter, Joel, 1971, "Trends and Patterns in U.S. and Worldwide Energy Consumption--a background review", Resources for Future Inc., February 1971 (available in draft. Scheduled to be published in 1972 as appendix to papers presented at RFF Forum on Energy, Economic Growth and the Environment, April 20-21, 1971, Washington, D.C.)

(g) Oral presentations to the Department of the Interior, June-July 1971, cited by Office of Oil and Gas in an informal compilation, July 16, 1971.

(h) U.S. D.I., Preliminary estimates by Bureau of Mines Staff, appended to statement of the Honorable Rogers C.B. Morton, Secretary of the Interior, before the Committee on Interior and Insular Affairs, United States Senate, June 15, 1971. Also presented in U.S.D.I., "United States Energy: A Summary Review," January 1972, p. 20.

(i) National Petroleum Council, "U.S. Energy Outlook: An Initial Appraisal, 1971 - 1985," Vol.I., July 15, 1971.

(j) Starr, Chauncey. "Energy and Power," Scientific American, vol. 225, No. 3 (September, 1971), p. 39. (Estimates of charted values).

(k) U.S. Bureau of Mines, Mineral Facts and Problems, 1970 Edition, Bulletin 650, Washington, 1970 (Table 4, pp.17 - 18).

(l) FPC-71: The 1970 National Power Survey, part 1: Federal Power Commission, Washington, D.C., March 1972.

(m) "Mr. [Gerard] Gambs is a veteran observer of the energy market who has worked in the coal, oil, and electric power sectors and is active in the forecasting efforts for the National Academy of Engineering's study on power plant siting" - Gordon.

(n) Schurr, Sam H., and Paul T. Homan, Middle Eastern Oil and the Western World, New York, American Elsevier, 1971.

(o) Henry Steele is a professor at the University of Houston; his estimate is cited by Gordon.

(p) Morrison, Warren E., "Impacts of Alternative Energy Systems", Proceedings of the Council of Economics of the A.I.M.E., San Francisco, California, February 20-24, 1972, pp. 147-178.

(q) The Chase Manhattan Bank, Energy Economics Division, "Outlook for Energy in the United States to 1985", June, 1972.

(r) DuPree, Walter G., Jr., and James A. West (U.S. Department of Interior) "United States Energy Through the Year 2000", December, 1972.

(s) U.S. Bureau of Mines, Press Release, "U.S. Energy Use at New High in 1971", March 31, 1972.

(t) National Petroleum Council (NPC), "U.S. Energy Outlook: A Summary Report of the National Petroleum Council," Washington, December, 1972.

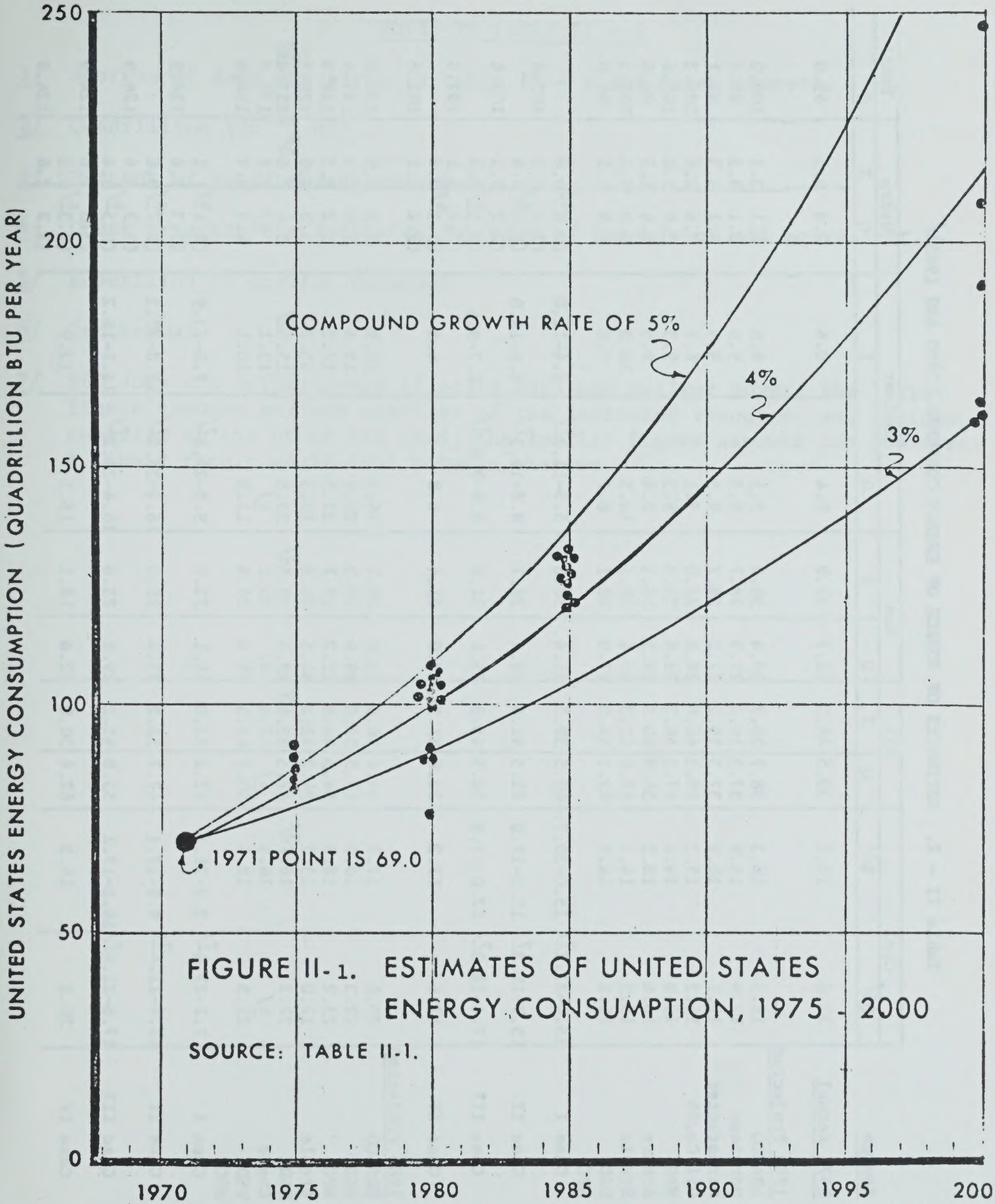


FIGURE II-1. ESTIMATES OF UNITED STATES ENERGY CONSUMPTION, 1975 - 2000

SOURCE: TABLE II-1.

Table II - 2. ESTIMATES OF SOURCE OF ENERGY CONSUMED, 1980 AND 1985 1/

Date	Source	Coal Q 2/	Coal % 3/	Oil Q	Oil %	Gas Q	Gas %	Nuclear Q	Nuclear %	Hydro Q	Hydro %	Total Q
	1971 Actual	12.6	18.2	30.5	44.2	22.7	32.9	0.4	0.6	2.8	4.1	69.0
	1980 Projected											
4-70	EBASCO	18.3	18.3	38.7	38.7	30.4	30.4	9.5	9.5	3.1	3.1	100.0
10-70	Morrison	17.9	18.9	37.3	39.2	27.2	28.7	9.5	9.9	3.1	3.3	95.1
2-71	Darnstadter	17.9	18.9	37.3	39.2	27.2	28.7	9.5	9.9	3.1	3.3	95.1
6-71	Oil Co.#4	16.2	15.3	49.3	46.8	28.4	27.0	7.1	6.7	3.6	3.4	105.3
7-71	NPC	19.9	19.4	47.3	46.1	22.5	21.9	9.5	9.3	3.0	3.0	102.6
?-71	Schurr	16.6	18.3	36.8	40.5	27.5	30.2	8.6	9.5	1.4	1.5	90.9
?-71	Steele	15.5	14.7	45.6	43.3	30.6	29.1	10.5	10.0	3.3	3.1	105.3
11-72	USDI	16.1	16.8	42.2	44.0	27.0	28.1	6.7	7.0	4.0	4.2	96.0
12-72	NPC											
	Case I	15.4-21.2 7/	15.0-20.7	40.5	39.5	31.4	30.6	5.5-11.3 7/	5.4-11.0	(0.8 6/	0.8	
										(3.2	3.1	102.6
	Case II	15.7-18.3 7/	15.3-17.8	42.5	41.4	29.4	28.7	8.8-11.3 7/	8.6-11.0	(0.4 6/	0.4	
										(3.2	3.1	102.6
	Case III	17.4-18.3 7/	17.0-17.8	46.5	45.3	25.4	24.8	8.9-9.8 7/	8.7-9.6	(0.3 6/	0.3	
										(3.2	3.1	102.6
	Case IV	17.6	17.2	52.8	51.5	22.0	21.4	6.8	6.6	(0.2 6/	0.2	
										(3.2	3.1	102.6
	1985 Projected											
4-70	EBASCO	20.6	17.2	44.4	36.9	35.0	29.1	16.5	13.9	3.5	2.9	120.0
6-71	USDI	22.3	16.7	47.5	35.6	39.4	29.5	20.8	15.6	3.4	2.6	133.4
7-71	NPC	23.2	18.5	54.5	44.6	22.2	17.7	21.5	17.2	3.2	2.5	124.9
?-71	Steele	17.0	13.2	54.2	42.2	34.5	26.8	19.5	15.2	3.3	2.6	128.5
2-72	USDI	22.3	16.7 5/	47.5	35.6 5/	39.4	29.5 5/	20.8	15.6 5/	3.4	2.6 5/	133.4 5/
6-72	Chase	4/	16.6	4/	47.4	4/	20.1	4/	13.1	4/	2.8	130.2
11-72	USDI	21.5	18.4	50.7	43.5	28.4	24.4	11.8	10.1	4.3	3.7	116.6
12-72	NPC											
	Case I	7.1-27.1 7/	5.7-21.7	42.2	33.8	41.1	32.9	9.8-29.8 7/	7.8-23.9	(1.4 6/	1.1	
										(3.3	2.6	124.9
	Case II	12.4-21.4 7/	9.9-17.1	47.7	38.2	35.4	28.3	16.2-25.2 7/	13.0-20.2	(0.7 6/	0.6	
										(3.3	2.6	124.9
	Case III	17.6-21.4 7/	14.1-17.1	53.8	43.1	29.5	23.6	16.4-20.2 7/	13.1-16.2	(0.5 6/	0.4	
										(3.3	2.6	124.9
	Case IV	20.3	16.3	62.4	50.0	22.6	18.1	16.1	12.9	(0.3 6/	0.2	
										(3.3	2.6	124.9

NOTES TO TABLE II - 2

1/ Sources of data are given in table II - 1 and notes thereto.

2/ Quadrillion (10^{15}) BTU.

3/ Percent of total energy consumed.

4/ Chase presents its estimates in terms of barrels of oil equivalent.

5/ Repetition of earlier forecast.

6/ Geothermal

7/ NPC does not definitively allocate coal and nuclear power; the larger figure assumes maximum supplies of the indicated resource, and minimum supplies of the other are used; the smaller figure assumes the converse. A likely result would fall between the two.

The potentials, problems, and environmental considerations related to individual energy sources other than geothermal resources are discussed in Chapter IV-D, Alternative Sources for Electrical Energy. Some of the major considerations are summarized in the following energy source discussions.

3. Natural Gas

Natural gas is considered the Nation's premium fuel due to its convenience, clean burning characteristics, and overall nominal adverse environmental impacts. Consumption of natural gas since 1966 has increased by one-third. Since 1968, the Nation has consumed approximately twice as much gas as it has found and added to its proven inventories. Forecasts of the future balance between the supply and demand for natural gas indicate that shortages may become progressively more severe. The Federal Power Commission has estimated that the gap between potential demand and the most likely available supply could reach 17.1 trillion cubic feet (37 percent of total demand and 58 percent of actual consumption) in 1990 even after liberal allowances for pipeline imports, liquefied natural gas imports, gas from coal and liquids, and Alaska gas (FPC, 1972).

As indicated in the President's 1973 Energy Message, the problem of natural gas supply results less from inadequate resources than it does from heavy Federal regulation. Such regulation involves both the operation of interstate natural gas pipelines and the price of natural gas supplied to these pipelines. As a result, price has been kept artificially low and demand has been artificially stimulated. Such regulation has resulted in a sharp reduction in exploration and development activities required to develop new resources for interstate markets to meet increasing demand.

To help correct this situation, the President has proposed that gas from new wells, gas newly dedicated to interstate markets, and the continuation of production of natural gas from expired contracts no longer be subject to wellhead price regulation. Such action should stimulate new exploration and development and increase supplies. Price increases also will be conducive to reducing inefficient uses and waste.

4. Coal and Oil

Forecasters generally have assumed that the difference between total energy consumption and availability of energy sources discussed thus far would be made up by consumption of coal and oil. In the "Initial Appraisal" of the National Petroleum Council, for example, that assumption was quite explicit (NPC, 1971). Domestic coal resources are ample, but the emissions of sulfur oxides and particulate air pollutants associated with coal uses under existing technologies and use systems make its combustion a problem from an air quality standpoint. Hazards to health and safety in underground mines and land reclamation requirements for strip mining also impose restrictions on coal supply.

Oil most often has been viewed as the "swing fuel" because additional imports of oil usually are assumed to be available from the Eastern Hemisphere. The high costs of domestic drilling and production, coupled with gradually declining real prices for oil, have reduced incentives for domestic production, and most projections have assumed constant or declining domestic production through 1985 to less than half of the Nation's supply needs. Most incremental oil supplies are expected to come from the Eastern Hemisphere.

In recent years, many have expressed concern over the level of domestic oil production and the disparity between the rising costs of drilling and production and the declining real price of oil. While oil prices are not explicitly regulated in the same fashion as gas, three governmental institutions have tended to keep the monetary price of oil constant: (1) market demand prorationing, (2) the oil import program (both of which have tended to keep supply and demand in balance at current prices), and (3) political pressure on prices. The market demand prorationing system no longer exerts an effective constraint, and the oil import program has been drastically altered by the Presidential Proclamation of April 18, 1973.

5. Nuclear, Hydroelectric, Geothermal, and Exotics

The future supply of nuclear power depends strongly on technology and economics. The current generation of nuclear reactors consumes uranium at efficiencies of a few percent. Development of breeder reactors could enhance conversion efficiency by providing for repeated use of nuclear materials, but breeders are unlikely to be in widespread use by 1985. Development of fusion reactors would permit extraction of nuclear energy from sea water, and thus reduce the pressure on uranium resources, but such development is unlikely before at least 1990. Meanwhile, conventional ("burner") reactors are being delayed by engineering and construction delays and problems of siting occasioned by concern over public safety and the environment.

Supplies of hydroelectric power are limited by the numer of additional dam sites that can be developed economically and in an environmentally acceptable manner. Most projections assume that supply of hydroelectric power will be determined by trends established in recent years.

Exotic energy sources such as fuel cells, solar energy, wind, etc. are unlikely to provide significant portions of domestic energy consumption before 1985.

While some projections consider geothermal energy, none suggest that it will provide a significant portion of total national energy consumption by 1985. However, it could have significant local area importance, particularly where it is near load centers or can be accommodated on existing transmission lines.

B. GEOTHERMAL ENERGY RESOURCES AND POTENTIAL

1. The Resource

a. What is Geothermal Energy?

Geothermal energy is the natural heat of the earth. Observations in mines and wells indicate that temperatures increase downward to between 200°C. and 1000°C. at the base of the earth's crust. 1/ The average heat flow of the earth is 1.5 x 10^{-6}cal/cm^2/sec., but known local variations in heat flow of 15 times this average have been found. Abnormally high heat flow areas are prospectively valuable for geothermal resource development. These areas are frequently, but not always, marked by hot springs.

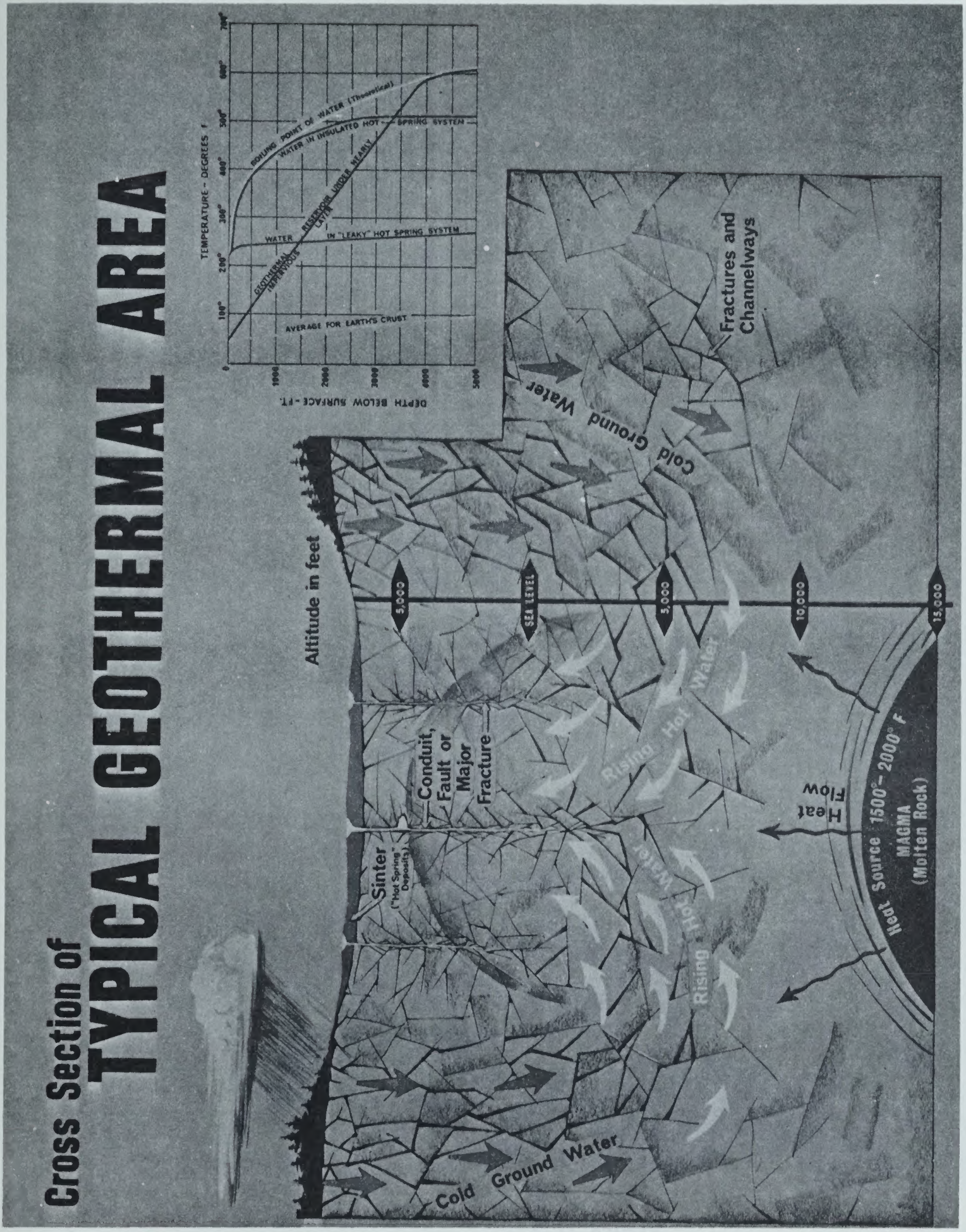
The natural heat of the earth is derived from radioactive decay, friction (tidal and crustal plate motion), and possibly primeval heat. Most of this heat is too diffuse to serve as a resource under present technology. Locally, however, it is concentrated in the crust by volcanism and tectonism and by convection cells of circulating hot waters above buried magma chambers. This heat is stored in rocks and in water and steam within pores and fissures. This water and steam serve to transfer the heat to the earth's surface.

b. Geothermal Systems

There are in essence four different major types of geothermal systems: vapor-dominated systems, hot water systems, geopressured reservoir systems, and hot dry rock systems. Most systems are divided into two types: the vapor-dominated or dry-steam system, and the liquid-dominated or hot water system. Heat for both systems is derived from a near-surface heat source such as a magma chamber. Surface and near surface water percolating through fractures is heated by the hot rock and rises, sometimes appearing at the surface in the form of hot springs, geysers, fumaroles, and other surface manifestations (Figures II-2 and II-3).

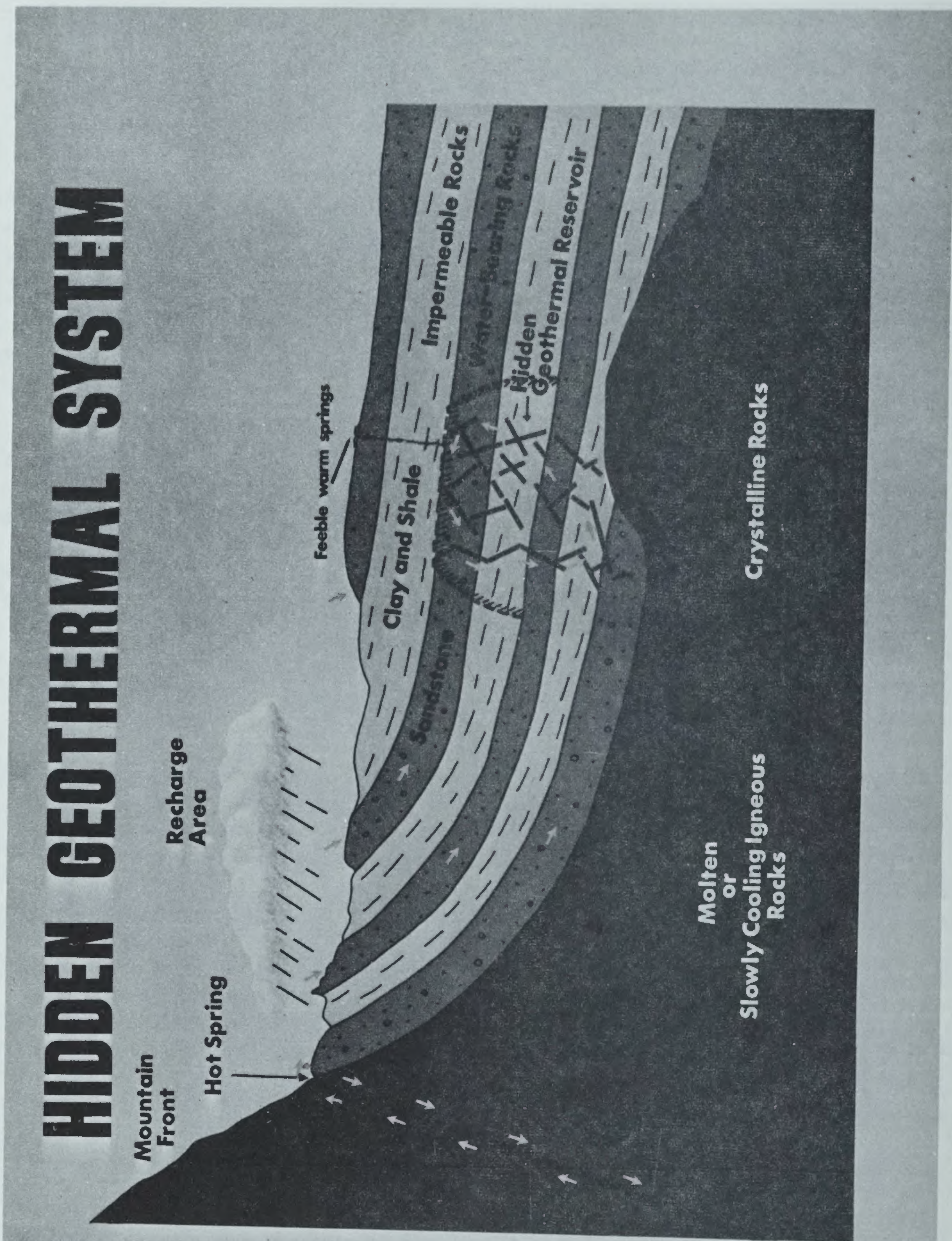
Vapor-dominated systems are believed to be relatively rare systems in which saturated steam and water are thought to coexist within the reservoir. The steam phase controls the pressure. With a decrease in pressure due to production through a well bore, the heat contained in the rocks dries and superheats the steam. Commercial well production ranges from 50,000 to 300,000 pounds of steam per hour. Power production from vapor-dominated fields occurs at The Geysers in California; Larderello, Italy; and Matsukawa, Japan. The Valles Caldera field currently under development in northern New Mexico appears to be vapor dominated. At least one of the hot spring systems in Yellowstone National Park is of this type but is closed to development by virtue of the park status.

1/ 392° F to 1832° F.



Source: Testimony for the Subcommittee on Water and Power Resources, Senate Committee on Interior and Insular Affairs., June 13, 1973.

Figure II-2



Source: Testimony for the Subcommittee on Water and Power Resources, Senate Committee on Interior and Insular Affairs, June 13, 1973.

Figure II-3

Hot water systems are thought to be thermally driven convective systems in which meteoric water picks up heat from a local heat source and moves upward in the system. This upwelling of hot water often penetrates to the surface and is manifested as hot springs, geysers, and other thermal surface phenomena. Thermal energy is stored both in the hot rock and in the water and steam which fill the pore spaces in the rock. Tapping of the upwelling hot waters by wells results in a portion of the fluid, generally 15 to 25 percent, flashing to steam due to pressure decrease. Temperatures of about 300° C and wellhead pressures from about 50 to 150 psi are commonly found in this type of system. The steam fraction is separated from the hot water at the surface. Steam is directed through the turbines and the hot water is discharged to the surface or reinjected into the ground. Electric power production from this type of system is presently underway at Wairkei, New Zealand; Otaka, Japan; Cerro Prieto, Mexico; and Pathe, Mexico.

Geopressured reservoir systems - Geopressured zones consist of highly porous sands saturated with brines of high temperature and very high pressure. They are located principally along the Louisiana Coast and offshore of southern Texas (Figure II-4). These zones are thought to occur as a result of normal heat flow being trapped by undercompacted clays which serve as an insulating layer. Waters derived from the compaction and dehydration of the clays accumulate in the sands and greatly increase the fluid reserve. The marine sediments are undercompacted below depths of 6,500 to 10,000 feet and the interstitial fluid carries part of the overburden load. Temperatures up to 290° C and pressures up to 500 atmospheres have been measured in these systems. Difficult technical and economic problems must be solved before this system may prove useful for the generation of electric power. Of prime concern is the capability of the reservoir to supply a sustained source of steam or very hot water to warrant the construction of a power plant. This system is still being developed.

Hot dry rock systems consist of impermeable rocks overlying a local heat source such as a magma chamber. A much larger volume of hot dry rock is located in the earth's crust at depths in excess of 50,000 feet, beyond present drilling capability. Some shallow hot rock systems such as one suspected to occur near Marysville, Montana, are subject to current research. Because of the absence of water in these systems, water would have to be introduced through wells and fractures in the rock between the wells. Steam brought to the surface will be used to run conventional turbines for the generation of electric power. Development of this system is in the early research state. Production of electric power from this system is probably years in the future.

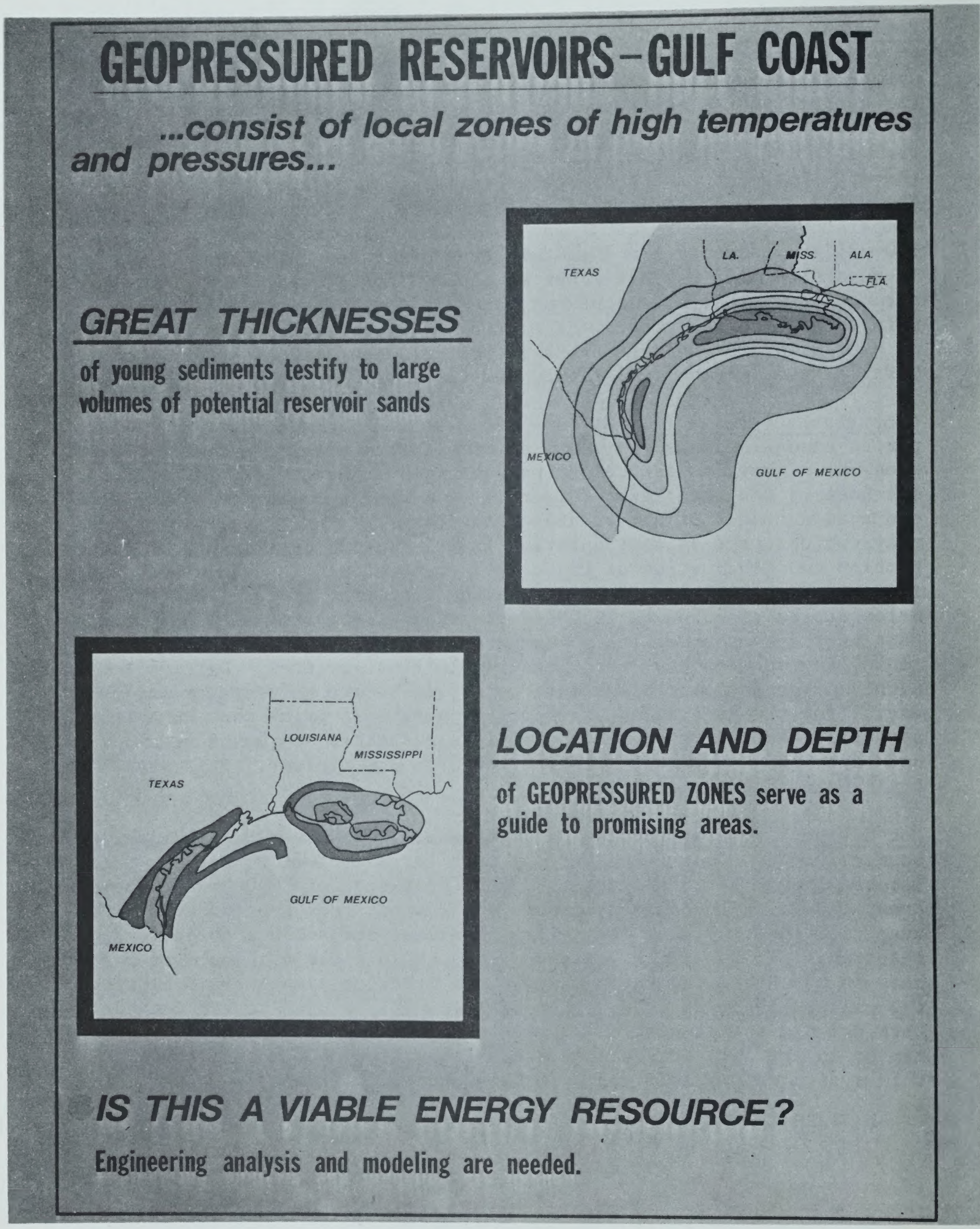


Figure II-4

Source: Testimony for the Subcommittee on Water and Power Resources, Senate Committee on Interior and Insular Affairs, June 13, 1973.

c. Utilization of Geothermal Resources

Potential uses of geothermal resources include power generation, space heating, agriculture, refrigeration, industrial processing, production of fresh water by desalination, and by-product chemical, mineral, and gas resources. Following are some present day examples of worldwide geothermal resources uses:

Electrical Power

United States	
The Geysers, California	298 MW (1972)
World	
Larderello, Italy	365 MW
Monte Amiata, Italy	26 MW
Wairakai, New Zealand	192 MW
Matsukawa, Japan	20 MW
Otake, Japan	12 MW
Cerro Prieto, Mexico	75 MW (1973)
Pathe, Mexico	½ MW
Namafjall, Iceland	3 MW
Pauzhetsk, USSR	5 MW

Space Heating

United States	
Klamath Falls, Oregon	over 400 buildings
Boise, Idaho	over 200 homes

World
- Iceland
- New Zealand
- Hungary
- USSR

Manufacturing and Processing

- Iceland
- New Zealand
- USSR

Refrigeration

- USSR

By-product Chemicals

- USSR

d. Location of Geothermal Resources

Identified recoverable geothermal resources in the United States are estimated at 2.5 x 10^{18} calories (10 x 10^{15} Btu). However, the distribution, extent, and magnitude of geothermal resources are not well known. The general extent of this resource in the United States can be inferred from the distribution of hot springs and young volcanic rocks in geopressured zones as shown in Figure II-5.

About 1.8 million acres of land in the western states have now been classified as "being within Known Geothermal Resources Areas (KGRA's)," according to the U.S. Geological Survey. An additional 96 million acres are listed as having "prospective value" for geothermal resources. Of the 1.8 million acres classified as KGRA's, where exploration for this energy resource is considered most promising, about one million acres of Federal land will be affected. Of the 96 million acres believed to have some potential, about 58 million acres of Federal land are involved.

2. Constraints on the Utilization of Geothermal Energy

a. Economic Constraints

The greatest potential for geothermal energy exists in the western part of the United States. This encompasses the Mountain and Pacific regions.1/ In 1971, installed capacity and net generation of this area was:

Area	Installed Capacity (Megawatts)	Net Generation (Million KW-hrs)
Mountain	19,010	80,034
Pacific	47,974	230,925
Total	66,984	310,959

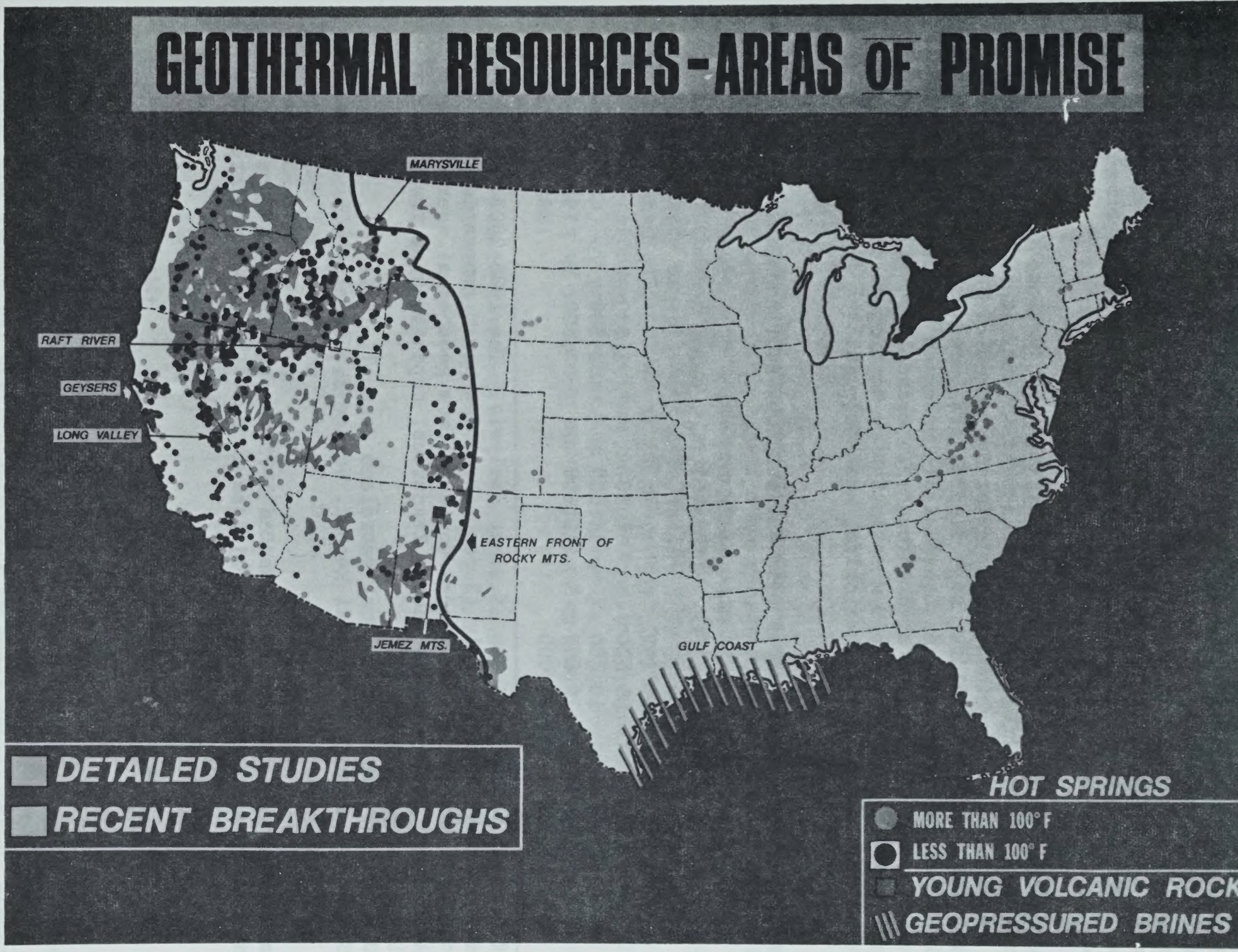
Future electrical generating capacity requirements in these regions with high geothermal potential are estimated to be:

Capacity Requirements2/ (Megawatts)

Year	Mountain Region	Pacific Region	Total
1973	24,400	70,600	95,000
1980	35,200	100,800	136,000
1985	49,600	141,200	191,000
2000	120,000	360,000	480,000

1/ The Mountain region consists of Arizona, Colorado, Montana, Nevada, New Mexico, Utah, and Wyoming. The Pacific region consists of California, Oregon, and Washington.

2/ Based on National Power Survey, FPC. 20 percent reserve requirements assumed.



Source: Testimony for the Subcommittee on Water and Power Resources, Senate Committee on Interior and Insular Affairs, June 13, 1973.

Figure II-5

Between now and 1975, some 362 megawatts of geothermal power in The Geysers area of California is expected to come on line, boosting geothermal electrical power to approximately 660 megawatts. Estimates beyond 1975 are difficult to make for this or other areas until more is known about the resource potential as a result of field investigations and development of technologies for using various geothermal fluids in environmentally acceptable manners.

Comparison of a number of the more significant projections for geothermal energy potential shows a wide spread in estimates. Low figures tend to be based on continuation of existing technology and development of relatively few new fields. High figures are based on assumptions concerning total resources, on considerable research and development funding, and on significant breakthroughs in technology. Future geothermal capacity over the minimum estimates is contingent on both resource development and technological breakthrough.

Geothermal energy estimates from various sources (in megawatts)

	1/	2/	3/ Case I	3/ Case IV	4/
1972	192	192			
1975	660	1,500	1,500	1,500	
1980	2,000	10,500	10,250	2,500	
1985	4,000	19,000	19,000	3,500	132,000
2000	40,000	75,000			395,000

1/ Estimates based on Bureau of Mines analysis. The 1985-2000 increase assumes that approximately 15 percent of new power generation capacity in the western states would be from geothermal sources.
2/ Assessment of Geothermal Energy Resources, Department of the Interior, 1972.
3/ U.S. Energy Outlook, National Petroleum Council, 1972.
4/ Geothermal Energy, a Special Report, Walter J. Hickel, 1972.

The major energy sources for the period 1975 through 2000, exclusive of geothermal resources, have been projected to be: (Dupree and West, 1972) (All figures in trillions of Btu).

Energy Source	1971[1]	1975	1980	1985	2000
Coal	12,560	13,825	16,140	21,470	31,360
Petroleum	30,492	35,090	42,190	50,700	71,380
Natural Gas	22,734	25,220	26,980	28,390	33,980
Nuclear Power	405	2,560	6,720	11,750	49,230
Hydropower	2,798	3,570	3,990	4,320	5,950
Total	68,989	80,265	96,020	116,630	191,900

[1] Actual

If it is assumed that development of geothermal resources would substitute for the need to develop an equivalent amount of electrical energy from the above sources, the various estimates for geothermal would represent approximately the following range of equivalent amounts and percentages of total energy, assuming a load factor of 80 percent for geothermal power:

	1985		2000	
	Tril. Btu	Percent	Tril. Btu	Percent
Bureau of Mines	280	0.2	2,800	1.5
Interior, 1972	1,330	1.1	5,250	2.7
NPC, Case I	1,330	1.1	--	--
Case II	245	0.2	--	--
Hickel, 1972	9,240	7.9	27,650	14.4

As is true for presently installed capacity, the bulk of the generating capacity in the area of high geothermal potential will be in the Pacific region. This could indicate economic constraints on geothermal energy unless the geothermal power plant is either (a) substantially closer to the load centers or (b) substantially lower in production costs, thus enabling transmission costs to be absorbed. Geothermal energy is a viable heat resource only when the total costs (including environmental control costs) of producting and distributing this power is lower than the total costs of producing and distributing power produced from other energy sources.

Broad estimates of the cost of producing new electrical power from various energy sources in the western states are:

Power Plant Type	Power Costs (Mills/kwh)
Geothermal (dry steam)	5.25 1/
Gas fired - steam	6.7
Coal fired - steam	8.2
Hydroelectric	9.6
Nuclear - steam	9.6
Geothermal (hot water)	9.7
Oil fired - steam	10.0

(See Ch. III, D. for additional detail)

In all instances it is assumed that the plant built will be at or near the scale frontier, i.e., the plant will represent the largest possible plant of that type with existing technology. For various technical reasons, the geothermal power plants will be small units; hence, transmission cost would be higher for moving power from the source to major load centers.

1/ By contrast, the cost of transmission may work in favor of geothermal in areas where loads are small and isolated.

b. Technological and Resource Information Considerations

The principal characteristics of a geothermal electrical generating plant that differ greatly from those of a fossil fueled plant are: (1) the greater amount of steam required by a geothermal plant to produce a kilowatt hour of electrical power, (2) their relatively small size, and (3) the absence of combustion of any fuel in a geothermal plant. The first two differences are responsible for limitations on the efficiency and economy of scale in geothermal plants.

Geothermal steam generating plants are small. Their capacity is governed largely by the steam reserves in the vicinity of the plant site, the flow of steam (or hot water) at each well supplying the plant, and the spacing of the wells and of the plants. A large flow of steam is required in geothermal units since temperature and pressure are low in comparison to fossil fueled (or nuclear) plants. The temperature of steam entering turbines at The Geysers is about 350° F and the pressure is about 100 pounds per square inch. In contrast, the turbine steam inlet temperature in a modern fossil-fueled plant is about 1,000° F and the pressure about 3,500 psi. The heat rate at The Geysers is nearly 22,000 Btu/kwh as compared with about 9,000 Btu/kwh for a modern fossil-fueled steam electric plant. The geothermal plant uses about 2½ times as many pounds of steam per hour for comparable electrical output.

Known geothermal resource areas and areas prospectively valuable for geothermal energy are nearly all in the western third of the United States and Alaska, except for the geopressured field along the Gulf Coast. With a few exceptions they are far from large load centers and are scattered over a wide area. Aside from the geothermal areas near the west coast of California, any large blocks of electric power generated from geothermal energy would have to be transmitted over considerable distances.

The Geysers field, which is about 80 miles north of San Francisco, is favorably located. Its present (1972) generating capacity is 298 MW and it is estimated to have a potential of 1000 to 3000 MW. The Imperial Valley geothermal area has the attractive feature of being near densely populated areas in southern California. Estimates of the potential for generating electrical power from geothermal resources underlying lands in the Imperial Valley area are based on limited knowledge. However, they indicate that electric power generated from these geothermal resources could supply a substantial portion of southern California's requirements.

At The Geysers there are 8 generating units. The largest units each have a generating capacity of about 55 MW. Generally, there is a pair of units at each generating station which provides a capacity of about

110 MW. By contrast, a modern steam electric generating unit has a capacity of about 800 MW. Some plants with several such units have capacities of several thousand megawatts.

The generating units at The Geysers are in a rectangular area about 4 miles long and 2 miles wide. Optimum spacing for these generating plants has been location of sites about a mile apart. Well depth varies from less than 1,000 feet to 9,000 feet. Part of the difference in depths is attributable to the fact that the altitude over the area varies from 1,500 feet to 3,200 feet. The steam output from an individual well ranges from 40,000 lb/hr from the shallow horizon to as much as 320,000 lb/hr from the deeper horizon.

Superheated hot water fields such as those found in the Imperial Valley area in southern California are now under investigation. A number of test wells have been drilled since 1961. The water temperature of the geothermal reservoirs in the Imperial Valley is considerably above atmospheric boiling temperature due to the confining pressure. The water contains high concentrations of dissolved minerals which may represent by-product potential; it also poses engineering problems such as corrosion, scaling, and disposal.

With the rising of hot water through any well tapping the geothermal resources of this area, the pressure would diminish. At the wellhead and during flow through a steam-water separator, the pressure would diminish further. Steam formed by vaporization accompanying the pressure reduction may represent approximately 20 percent of the water produced by the well. This steam would be available for power generation.

A technological innovation currently receiving attention could make possible the generation of electric power by utilizing some of the heat in water at temperatures below atmospheric boiling point as well as higher temperature water. In this new system, a low boiling point fluid such as isobutane or freon is vaporized in a heat exchanger, which transfers heat from water supplied by geothermal wells to the low boiling point fluid. In an isobutane system, for example, the isobutane vapor builds up pressure to drive a turbine. After expanding through the turbine, the isobutane is condensed and returned to the heat exchanger and the cycle is repeated. Water from geothermal wells after passing through the heat exchanger can be reinjected into the geothermal reservoir.

A small plant of this type has been built in the USSR, and development work on components of the system is being conducted in the United States. If such technology is proved to be economically viable, it could apply to geothermal reservoirs whose temperatures are too low for steam production, a rather large segment of the potential geothermal resources. It also would make possible utilization of a greater portion of the heat than is possible with present technology in higher temperature hydrothermal systems. Low boiling point fluid process also may offer a means of reducing scaling

and corrosion problems in power generation plants. This technology appears to have some attractive features; however, any judgment at present as to how soon and the extent to which it may find industrail application would be conjectural.

Beneath the northern Gulf coast is a geopressured field, a sedimentary basin in which interstitial hot water is confined under higher pressure than ordinary for the depths involved. Sedimentary basins of this type at other locations in the United States are known, but they appear to have less appeal at the present time. The geothermal energy in these sedimentary basins may represent a significant resource potential. However, determination of its significance must await resource assessment studies, demonstration of recovery technology, and determination of economic feasibility.

Hot, dry rock may represent a significant potential geothermal energy resource. Recovery of heat from this source is not economic at present. Determining its significance as a future energy source will depend, among other things, on (1) ascertainment of the availability of rock at sufficiently high temperature at depths less than 10,000 feet, assuming present drilling techniques, and (2) development of technology for recovering energy from dry, hot rock.

Conceptual studies of recovery methods from hot, dry rock have been made. Basically, these methods involve fracturing the rock to provide passageways, injecting water into the fractured area, heating of water (and steam in some instances) by the hot rock, and using the energy absorbed by the water (or steam) to generate electric power. Two methods of fracturing and subsequent energy recovery have been proposed.

One method proposes a technique known as hydraulic fracturing or "hydrofracing," a technique used by the oil industry. In this method a hole is drilled into the hot zone. Water is forced into the hole under sufficient pressure to cause fracturing of the rock. Additional fracturing (thermal fracturing) results from thermal stresses induced by temperature changes. A second hole is drilled into the upper part of the fractured zone. Injected water flowing through the fractured zone absorbs heat and the heated water flows to the surface through the second hole. The hot water, under pressure, flows through a heat exchanger, which transfers the heat to a secondary fluid that serves as the working fluid in a power generation cycle.

Another method that has been suggested envisions the use of a nuclear explosive in hot, dry rock, resulting in formation of a cavity filled with rubble and a fractured zone surrounding the rubble. Water might be introduced into the bottom of the cavity. Relatively high temperature, high pressure steam would be formed in a cavity. This steam, transmitted to the surface, could be used to generate power. The condensed steam might be returned to the bottom of the underground cavity, whereupon the cycle could be repeated. While this method may have potential at some

future date, much research and development will be required and significant environmental impacts could be involved. Currently, no research of this method is being conducted. Prior to such research a thorough environmental evaluation would have to be conducted. (Discussion of nuclear stimulation of gas reservoirs is included in Ch. IV, Section 4, Alternative Sources for Electrical Energy.)

A number of potential technological problems are associated with these systems, and questions relating to technical feasibility can be answered only by research and development efforts and eventual field tests. In addition, environmental and public acceptance problems will have to be solved. Firm assessment of economic feasibility also must await the outcome of research, development, testing, and actual production programs.

Undoubtedly, the amount and intensity of future research and development effort will have an important bearing on the rate of development of geothermal resources. Along with other factors, known technology and some of the technology under development can be expected to lead to growth of the geothermal industry to a few thousand megawatts during the next 10 or 12 years. Depending on the intensity of research and development effort, totally new, undeveloped technology may come into commercial practice on a significant scale in 10 to 20 years. From the standpoint of such anticipated geothermal energy production technology, rapid growth of the industry could be expected during the last 15 or 20 years of this century.

C. DEVELOPMENT OF GEOTHERMAL RESOURCES

Development and production of geothermal resources involve six phases: exploration, test drilling, production testing, field development, powerplant and powerline construction, and full-scale operations. Each successive step is dependent upon successful results in the previous phases. Because of limited knowledge of the occurrence, location, and properties of geothermal resources as related to both energy and by-product water and mineral materials, it is not possible in this general statement to specifically predict the success or failure of any lease site or to make a categorical prediction about the program as a whole. However, the probabilities are believed good that several new geothermal fields comparable to those already proven commercial for energy production will be developed and that significant economic production of fresh water and minerals also may result.

Geothermal reservoir systems can be divided into two broad categories on the basis of the fluid produced: (1) vapor-dominated (dry steam) systems, and (2) hot-water systems (Appendix G). The vapor-dominated systems yield steam and other gases with little or no associated water. The hot-water systems (Figures II-6 and II-7) yield water, and if the temperature is sufficiently high, some of the water flashes to steam, which can be directed through turbines to generate electricity. The commercial-scale geothermal power development at The Geysers, California, is a vapor-dominated system; however, most hot-springs systems in the United States, including most of KGRA's, yield fluids that are dominated by hot water rather than by steam.

Exploration for geothermal reservoirs of commercial value in both known and potential geothermal resource areas includes topographic mapping, geologic mapping and field investigations, ground and spring temperature surveys, geochemical sampling, geophysical surveys and shallow informational drilling.

Test wells may vary, depending on the geological conditions and the objectives, from boreholes with diameter of about 4 inches to 24 inches and in depth from a few hundred to several thousand feet, with the deepest in the 5,000 to 10,000-foot range. The equipment and the control measures for drilling, sampling, and completion have to be appropriate for different situations. Where the principal objective is to outline prospective areas by collecting data on thermal gradients or geologic structure, and steam-producing zones will not be penetrated, small diameter boreholes may be put down by small or medium-sized drill rigs to a depth of about 2,000 feet. For test wells intended to investigate the potential reservoirs with large diameter and deeper boreholes, the current drilling equipment, technology, and methods are similar to those used in oil and gas operations (Figure II-8).

A test well which has intersected a geothermal reservoir with favorable temperature, fluid composition, and formation characteristics generally leads to the drilling of a production well and production testing of the

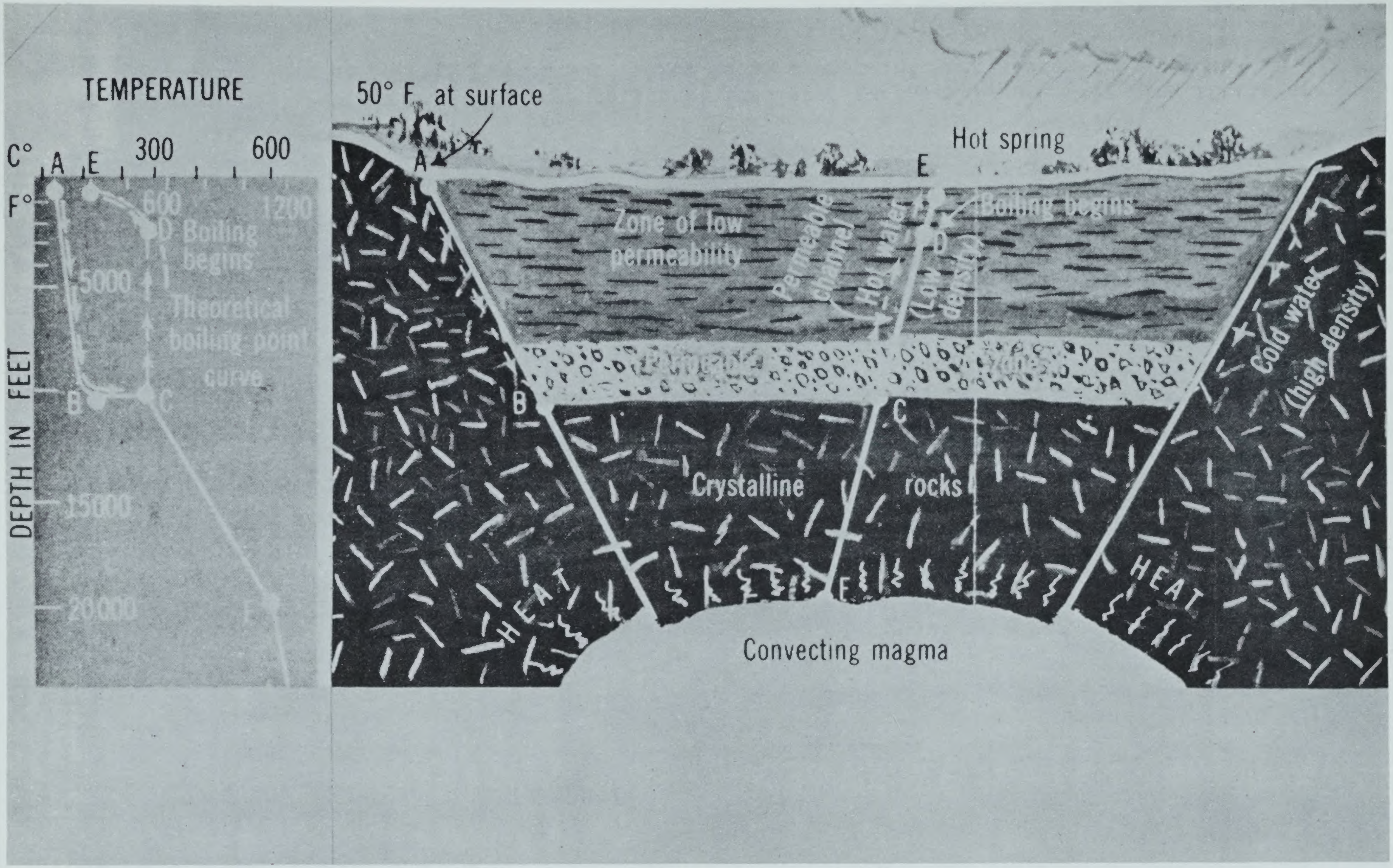


Figure II-6. Diagramatic representation of hot spring system with high rate of upflow.

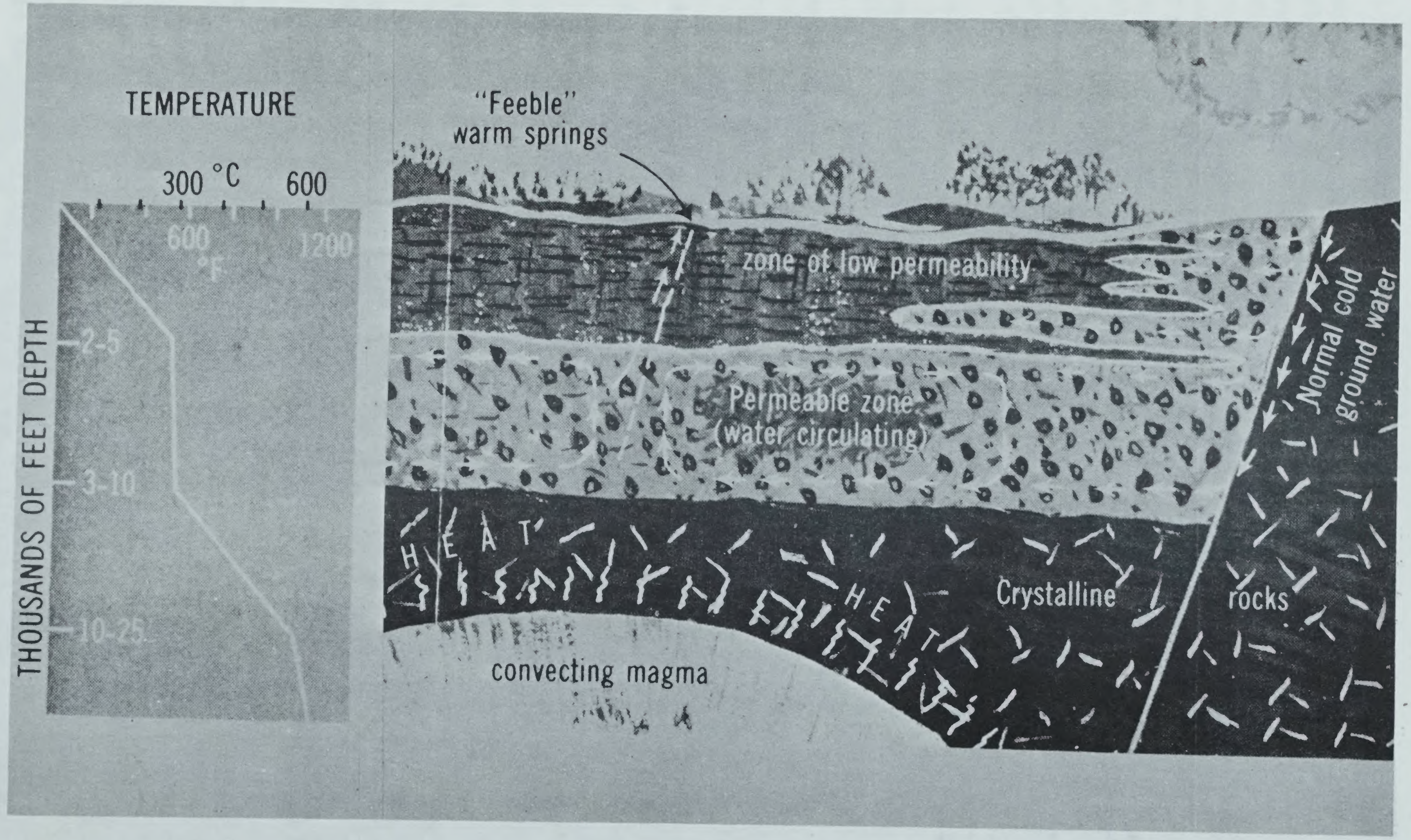


Figure II-7. Diagramatic representation of insulated geothermal reservoir with little or no leakage. Imperial Valley is an example of such systems.

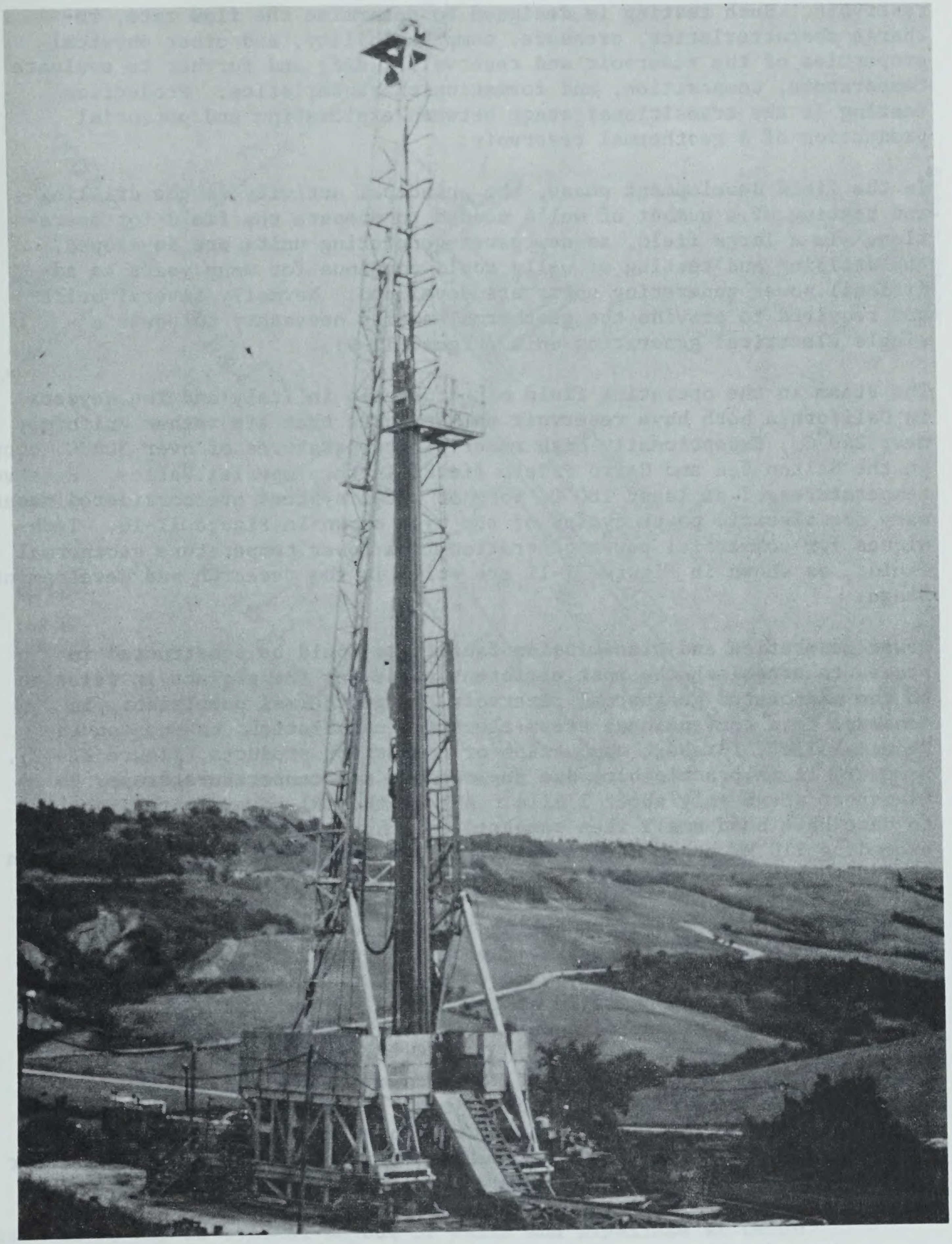


Figure II-8. Typical drilling rig used for geothermal exploration and development, Larderello, Italy

reservoir. Such testing is designed to determine the flow rate, recharge characteristics, pressure, compressibility, and other physical properties of the reservoir and reservoir fluids and further to evaluate temperature, composition, and formation characteristics. Production testing is the transitional stage between exploration and potential production of a geothermal reservoir.

In the field development phase, the principal activity is the drilling and testing of a number of wells needed to prepare the field for operation. In a large field, as new power-generating units are developed, the drilling and testing of wells could continue for many years as additional power generating units are developed. Normally several wells are required to provide the geothermal energy necessary to power a single electrical generating unit (Figure II-9).

The steam in the operating field of Larderello in Italy and The Geysers in California both have reservoir temperatures that are rather uniformly near 240°C. Exceptionally high reservoir temperatures of over 300°C. occur in the Salton Sea and Cerro Prieto fields in the Imperial Valley. Reservoir temperatures of at least 180°C. for hot water systems are considered necessary for electric power cycles of the type shown in Figure II-10. Techniques for commercial power generation from lower temperature geothermal fluids, as shown in Figure II-11 are still in the research and development stage.

Power generation and transmission facilities would be constructed in stages to establish the most efficient scope for the project in relation to the associated geothermal reservoir. A geothermal powerplant, in contrast to a conventional steam-electric installation, has no conventional boiler, firebox, combustion or combustion products (Figure II-12). However, it is practicable, due to pressure and temperature drops, to transport steam only about 1 mile. All geothermal powerplants installed to date have been small when compared to other types of powerplants, not exceeding 110 MW at an individual site. It is expected that this pattern of development will continue.

Electrical-energy generation during full-scale operations would be at its maximum and generally may be expected to continue at approximately the full-scale level for many years. All initial facilities associated with production and conversion of geothermal energy, and byproduct, facilities, e.g., a processing plant for extracting valuable chemicals or minerals from geothermal fluids, and/or facilities for producing and perhaps storing fresh water might serve as a pilot plant for making improvements and additions to the project. Likewise, operation of a plant addition might provide useful data for planning and designing the next addition. Data would be accumulated from the outset by the operator and would be available for designing environmental safeguards, as well as for designing other types of improvements.

The processing for fresh water and minerals as byproducts is expected to be of commercial interest at some geothermal installations. Another

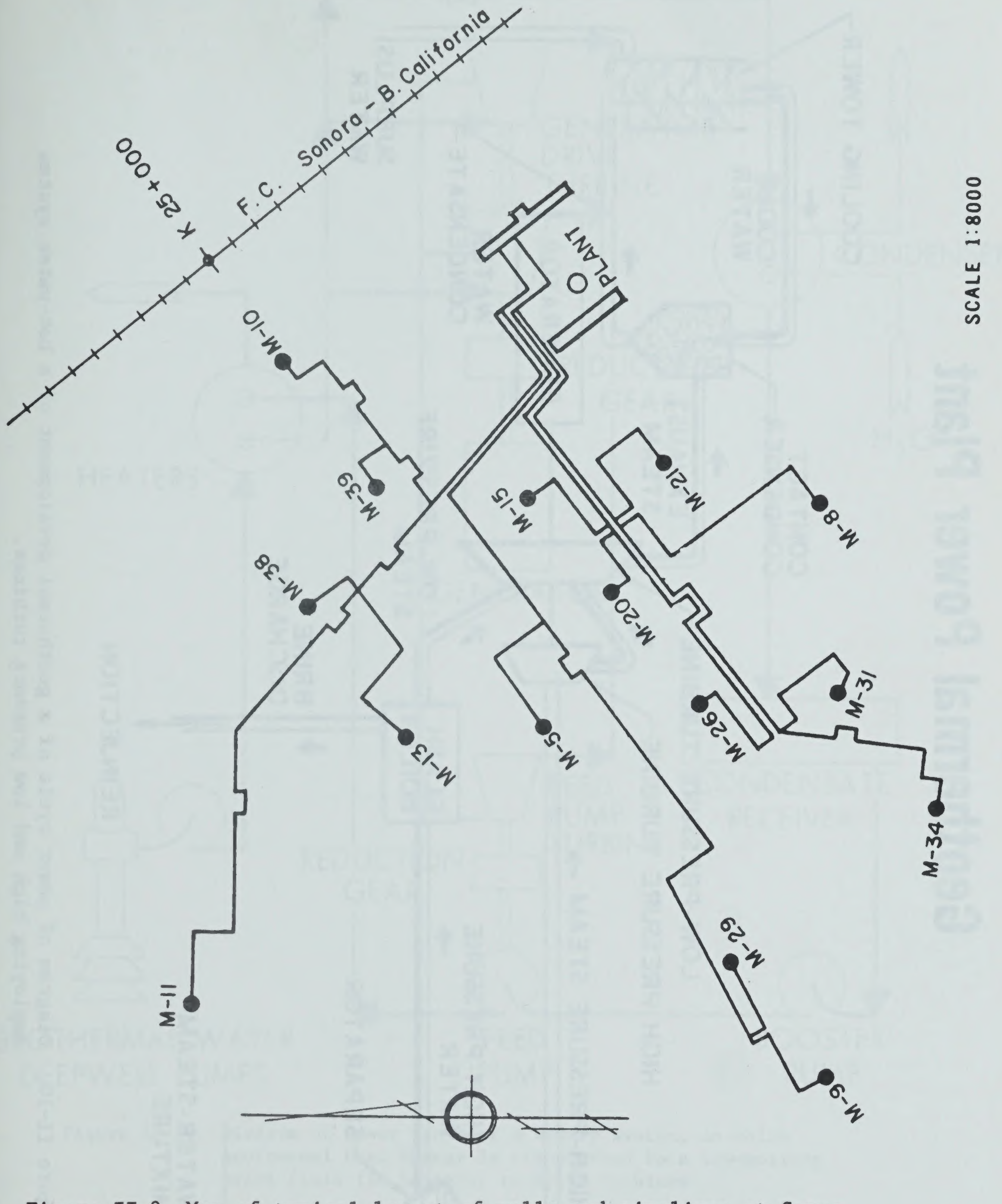


Figure II-9. Map of typical layout of wells and pipelines at Cerro Prieto Field, Mexico

Source: Cerro Prieto, Energia del subsuele, comision federal de electricidad, Mexico City, 1971

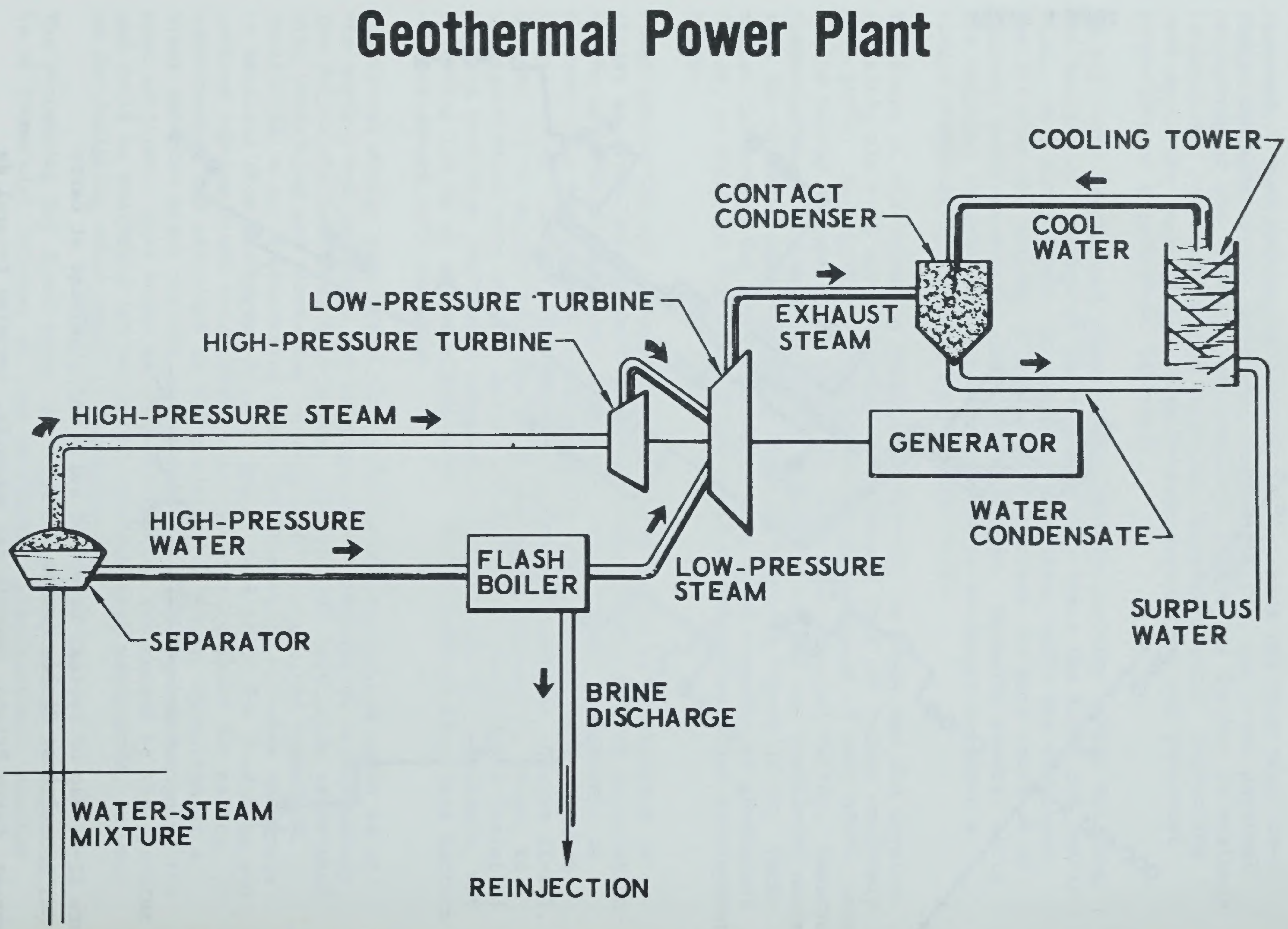


Figure II-10. Diagram of power cycle of a geothermal development of a hot-water system employing high and low pressure turbines.

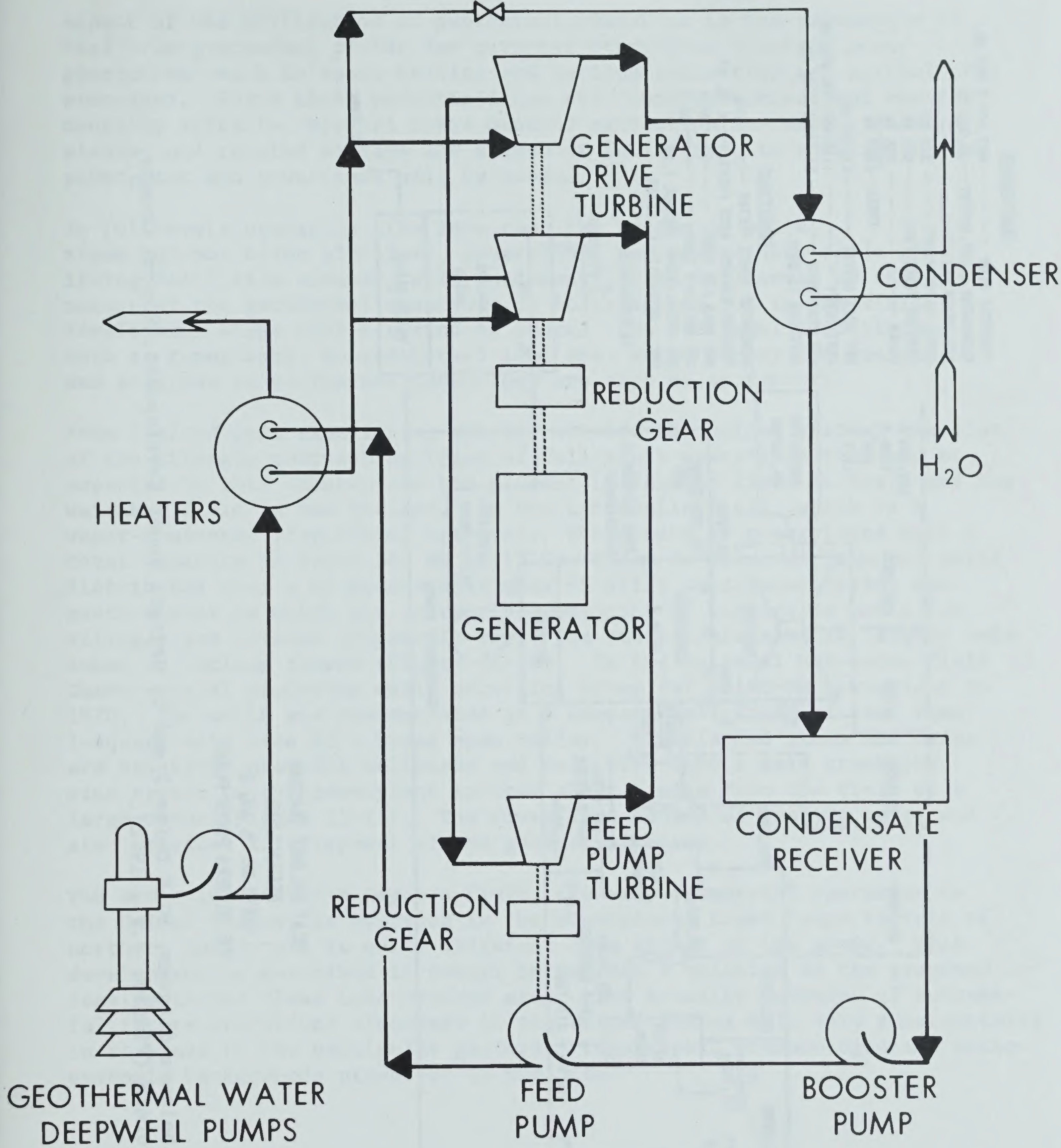


Figure II-11. Diagram of power cycle of a binary system, in which geothermal heat energy is transferred to a low-boiling point fluid (in heaters) to drive turbines

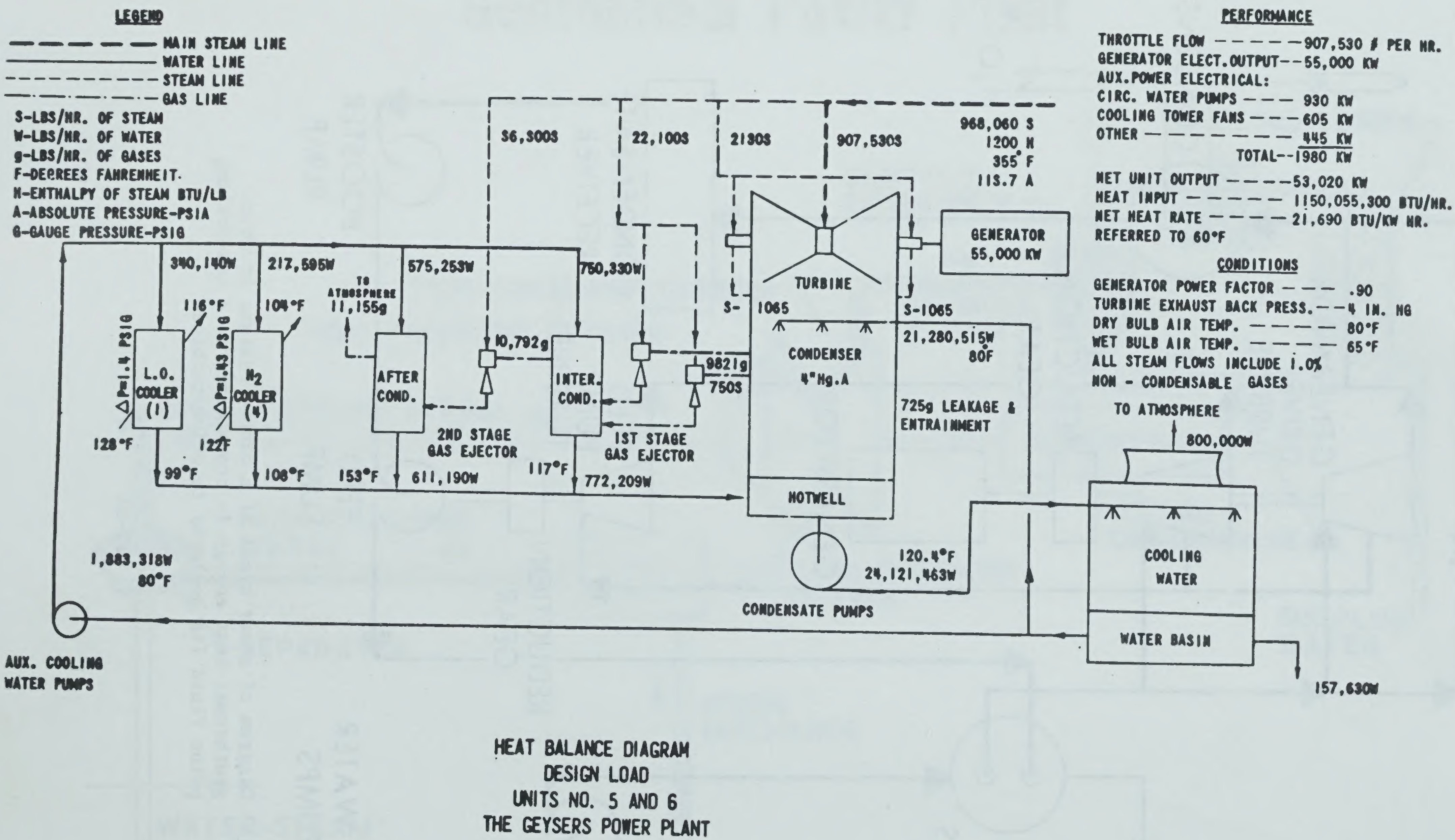


Figure II-12. Heat balance diagram, PG&E Units 5 and 6, Geysers Power Development, Sonoma County, California (Finney, J.P., 1972).

aspect of the utilization of geothermal resources is the extraction of heat from geothermal fluids for purposes other than electric power generation--such as space heating and various industrial and agricultural processes. Where these potentialities are found economical and environmentally suitable, special large mineral extraction and water-treatment plants, and related storage and transport facilities, in addition to the powerplant and powerlines will be needed.

In full-scale operation, the form that the system of wells, steam and hot brine pipelines, powerplants and powerlines, roads and living facilities assumes, will fundamentally be influenced by the nature of the geothermal reservoir as it is worked out in the field development stage over a period of years. The surficial conditions--such as topography, nongeothermal land use, water supply for cooling, and progress in geothermal technology are also major factors.

From limited past experience, chiefly outside the United States, examples of the strongly contrasting types of full-scale operations that may be expected in this country are the pioneer Larderello field in Italy and the Wairakei field in New Zealand. In the Larderello field, which is a vapor-dominated (dry steam) reservoir, there were 13 powerplants with a total capacity of about 360 MW in 1970. Steam is obtained from 467 wells distributed over a 65-square mile area of hilly cultivated fields and pasturelands in which the attractive community of Larderello and a few villages are located (Figure II-13). The steam condensate is largely consumed in cooling towers (Figure II-14). In the Wairakei hot-water field there were 61 producing wells providing steam for a 160-MW powerplant in 1970. The wells are concentrated in a compact well field of less than 1-square mile area in a broad open valley. The flashed steam and brine are separated near the wellheads and collected into a main trunkline pipe system to the powerplant located about 1 mile from the field on a large river (Figure II-15). The river is a source of cooling water and also provides for disposal of the geothermal brine.

The style in which The Geysers field, the only commercial operation in the United States, is evolving in the mountainous Coast Range terrain of northern California is quite different from either of the above. This development is described in detail in Chapter V relative to the proposed leasing in the Clear Lake-Geysers area. The specific patterns of successful future operations elsewhere in the United States will vary substantially in response to the particular geologic, topographic, technologic and socioeconomic backgrounds prevalent in the area.

Figure II-13. Compatible land use at Larderello Field, Italy. Steam lines crossing grain fields and vineyards involve minimum use of land for geothermal development.

Figure II-14. Natural draft cooling towers employed at Larderello geothermal development, Italy.

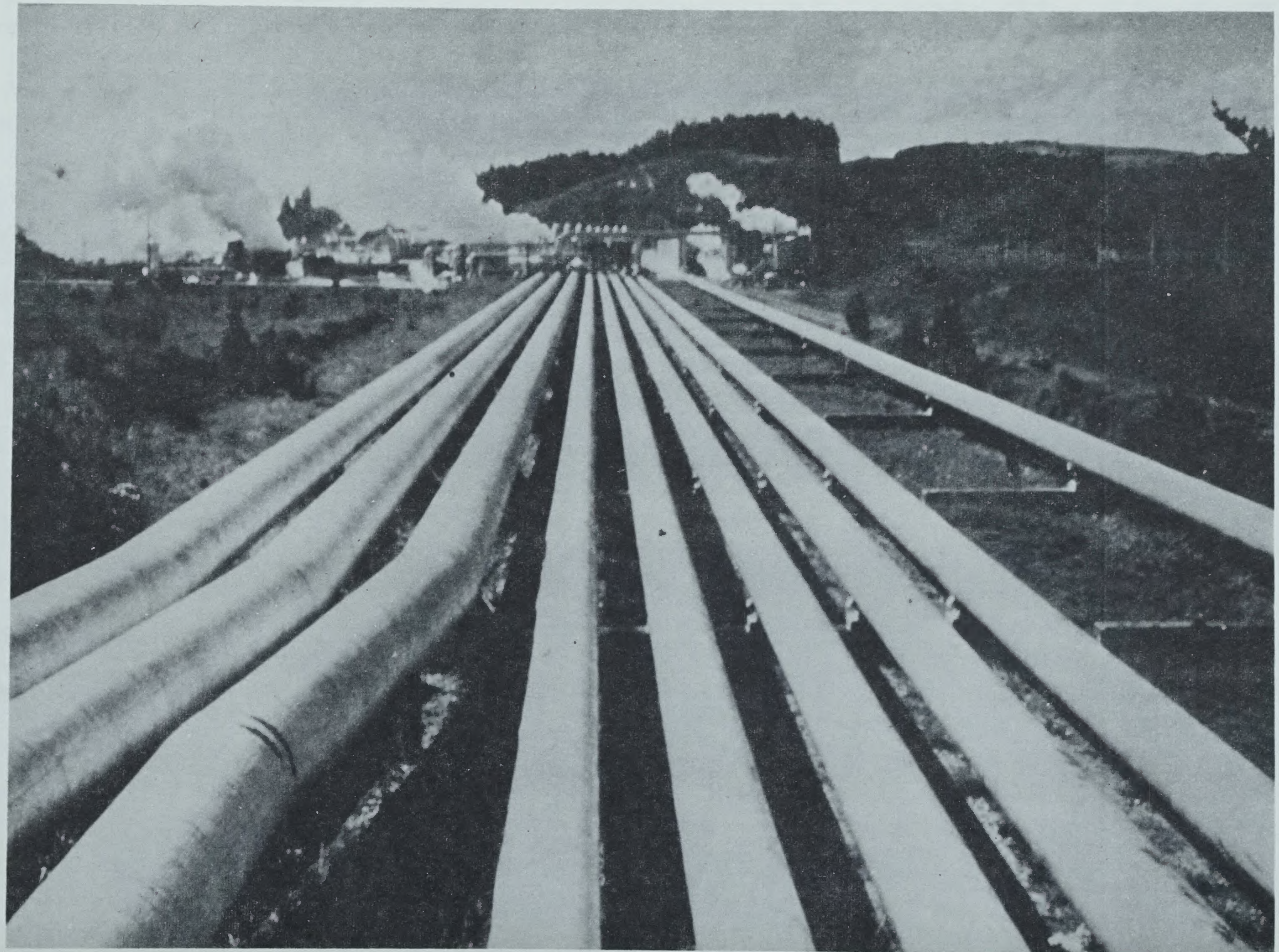


Figure II-15. Wairakei Geothermal Field. View of steam collector lines approaching powerplant.

D. DESCRIPTION OF THE ENVIRONMENT

Public land ownership varies widely in the western states. Table II-3 shows the acreage and percentage of Federal ownership by states. Figures II-16 and II-16a show the location and the Federal land ownership percentage relationships for the 11 contiguous western states. Section 3 of the Geothermal Steam Act of 1970 defines the portion of the public lands potentially available for geothermal leasing. These include principally: (1) public, withdrawn, and acquired lands administered by the Secretary of the Interior (approximately 451 million acres in 25 states); (2) national forests and other lands administered by the Forest Service, Department of Agriculture (approximately 187 million acres in 45 states and Puerto Rico); and (3) lands containing a reservation to the United States of the geothermal resources. These lands total 638 million acres.

The Known Geothermal Resources Areas (KGRAs) and lands considered prospectively valuable for geothermal resource development are scattered throughout the western states of Alaska, Washington, Oregon, California, Nevada, Idaho, Montana, Wyoming, Utah, Arizona, New Mexico, Colorado and South Dakota. These geothermal resource areas contain about 57 million acres of Federal land or about 9 percent of the total Federal acreage. In these areas, higher than normal temperature gradients are likely to occur and there is a reasonable possibility of finding reservoir rocks that will yield steam or heated fluids to wells at depths accessible by present drilling technology. Most geothermal leasing probably will be confined to these geothermal resource areas.

The geology of the western United States, including Alaska, is very complex. The stratigraphy includes rocks from Pre-Cambrian to Holocene Age, structures from simple to complex, and a variety ot tectonic regimes, including active fault zones with associated earthquakes. Geothermal resource areas are those that include Tertiary or Quaternary volcanic areas; areas which have geysers, fumaroles, mud volcanos, or thermal springs, and areas with subsurface geothermal gradients in excess of two times normal. Because the geology of each geothermal resource area may be different, detailed geologic discussions are possible only on a site-by-site basis.

The terrain of the geothermal lands is diverse, encompassing lands in the Great Basin, the Rocky Mountains, the mountains along the Pacific Coast, and Cascade Range, and the Aleutian Islands. These lands include forests, grasslands, high and low desert lands, lands covered by tundra and agricultural lands.

Mean annual precipitation of the western United States ranges from lows of 0-8 inches per year in desert regions to highs in excess of 128 inches along the northwest Pacific coast and in some high mountain regions. Temperatures are widely variable over the region, with some locations averaging in excess of 300 frost-free days per year to areas with under 60 frost-free days per year (Geological Survey, 1970, National Atlas).

Vegetation varies from desert and tundra types to humid coastal forests. Existing land-use patterns and management principally include mining and mineral operations, timber production, livestock grazing, fish and

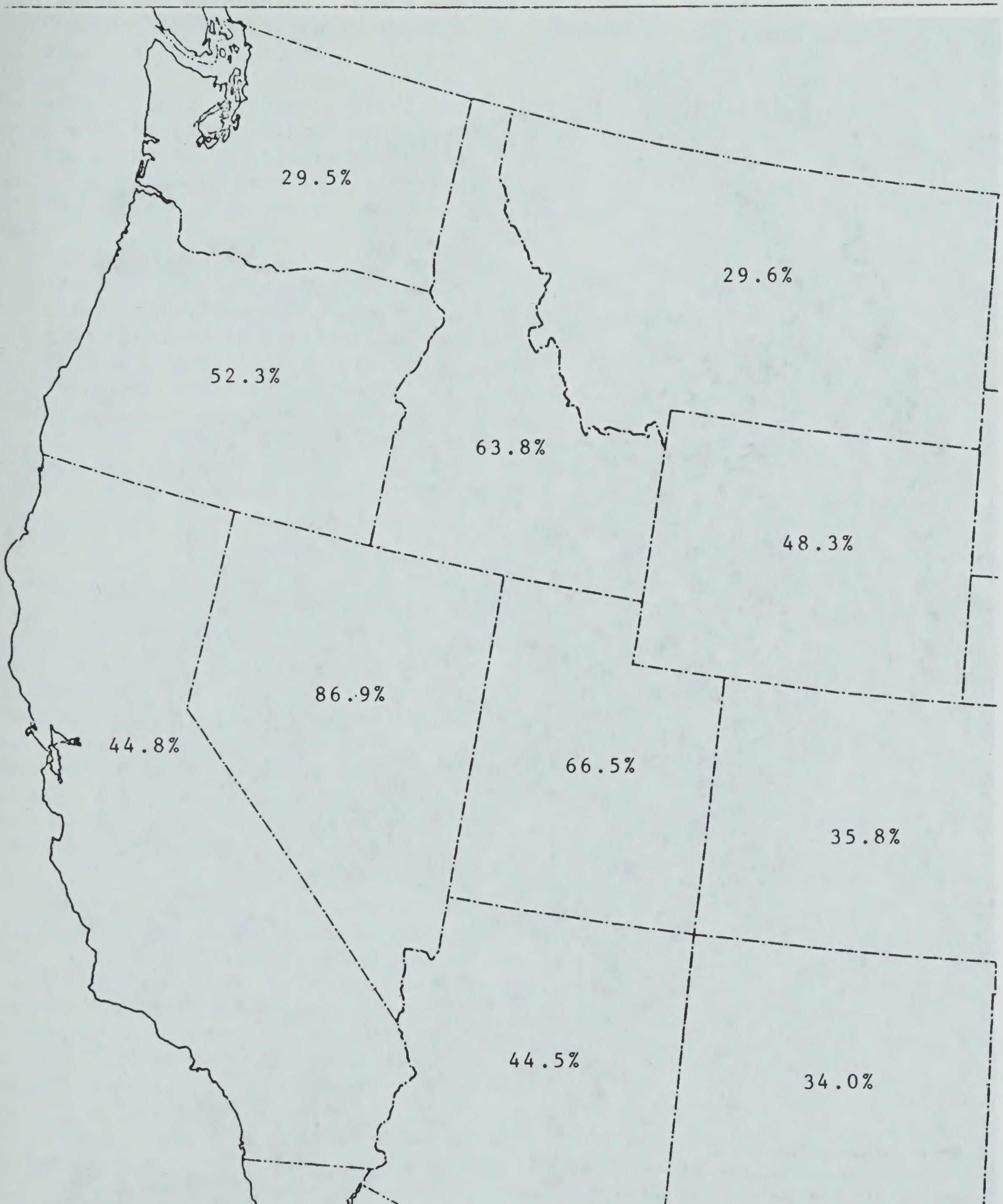
Comparison of federal owned land with total acreage of States as of June 30, 1970

State	Acreage owned by the Federal Government			Acreage not owned by Federal Government	Acreage of State[1]	Percent owned by Government
	Public domain	Acquired by other methods	Total			
Alabama	26,703.4	1,075,354.7	1,102,058.1	31,576,341.9	32,678,400	3.372
Alaska	353,403,875.1	141,601.1	353,545,476.2	11,936,123.8	365,481,600	96.734
Arizona	32,037,265.8	299,311.2	32,336,577.0	40,351,423.0	72,688,000	44,487
Arkansas	1,067,783.0	2,099,499.8	3,167,282.8	30,432,077.2	33,599,360	9.427
California	42,613,739.6	2,290,133.1	44,903,872.7	55,302,847.3	100,206,720	44.811
Colorado	23,122,630.8	654,613.2	23,777,244.0	42,708,516.0	66,485,760	35.763
Connecticut	0	9,338.9	9,338.9	3,126,021.1	3,135,360	.298
Delaware	0	39,253.0	39,253.0	1,226,667.0	1,265,920	3.101
District of Columbia	0	10,335.3	10,335.3	28,704.7	39,040	26.474
Florida	370,941.6	3,045,014.2	3,415,955.8	31,305,324.2	34,721,280	9.838
Georgia	0	2,147,991.9	2,147,991.9	35,147,368.1	37,295,360	5.759
Hawaii	0	396,900.7	396,900.7	3,708,699.3	4,105,600	9.667
Idaho	33,016,681.3	780,420.7	33,797,102.0	19,136,018.0	52,933,120	63.849
Illinois	408.2	551,864.9	552,273.1	35,242,926.9	35,795,200	1.543
Indiana	432.0	440,751.7	441,183.7	22,717,216.3	23,158,400	1.905
Iowa	340.8	219,904.1	220,244.9	35,640,235.1	35,860,480	.614
Kansas	26,734.8	653,978.6	680,713.4	51,830,006.6	52,510,720	1.296
Kentucky	0	1,269,081.6	1,269,081.6	24,243,238.4	25,512,320	4.974
Louisiana	19,499.7	1,020,838.0	1,040,337.7	27,827,502.3	28,867,840	3.604
Maine	0	130,297.0	130,297.0	19,717,383.0	19,847,680	.656
Maryland	0	194,753.6	194,753.6	6,124,606.4	6,319,360	3.082
Massachusetts	0	77,434.0	77,434.0	4,957,446.0	5,034,880	1,538
Michigan	291,852.4	3,068,464.2	3,360,316.6	33,131,843.4	36,492,160	9,208
Minnesota	1,287,157.5	2,031,457.7	3,318,615.2	47,887,144.8	51,205,760	6.481
Mississippi	5,528.7	1,570,972.6	1,576,501.3	28,646,218.7	30,222,720	5.216
Missouri	2,604.3	1,948,169.0	1,950,773.3	42,297,546.7	44,248,320	4.409
Montana	25,129,785.2	2,500,223.6	27,630,008.8	65,641,031.2	93,271,040	29.623
Nebraska	260,400.6	461,040.2	721,440.8	48,310,239.2	49,031,680	1.471
Nevada	60,895,195.2	154,265.4	61,049,460.6	9,214,859.4	70,264,320	86.885
New Hampshire	0	707,413.2	707,413.2	5,061,546.8	5,768,960	12.262
New Jersey	0	118,096.0	118,096.0	4,695,344.0	4,813,440	2.453
New Mexico	24,804,919.7	1,596,721.3	26,401,641.0	51,364,759.0	77,766,400	33.950
New York	0	234,582.1	234,582.1	30,446,377.9	30,680,960	.765
North Carolina	0	1,949,441.3	1,949,441.3	29,453,438.7	31,402,880	6.208
North Dakota	207,648.0	1,942,194.6	2,149,842.6	42,302,637.4	44,452,480	4.836
Ohio	85.0	290,071.3	290,156.3	25,931,923.7	26,222,080	1.107
Oklahoma	149,498.1	1,299,625.4	1,449,123.5	42,638,556.5	44,087,680	3.287
Oregon	30,997,834.3	1,211,468.5	32,209,302.8	29,389,417.2	61,598,720	52.289
Pennsylvania	0	632,424.8	632,424.8	28,172,055.2	28,804,480	2.196
Rhode Island	0	7,772.1	7,772.1	669,347.9	677,120	1.148
South Carolina	0	1,135,107.6	1,135,107.6	18,238,972.4	19,374,080	5.859
South Dakota	1,593,702.7	1,752,047.5	3,345,750.2	45,536,169.8	48,881,920	6.845
Tennessee	0	1,732,897.9	1,732,897.9	24,994,782.1	26,727,680	6.484
Texas	0	3,047,528.1	3,047,528.1	165,170,071.9	168,217,600	1,812
Utah	34,501,694.2	520,353.6	35,022,047.8	17,674,912.2	52,696,960	66.459
Vermont	0	264,308.5	264,308.5	5,672,331.5	5,936,640	4.452
Virginia	0	2,219,807.0	2,219,807.0	23,276,513.0	25,496,320	8.706
Washington	11,130,587.5	1,469,765.5	12,600,353.0	30,093,407.0	42,693,760	29.513
West Virginia	0	1,023,491.8	1,023,491.8	14,387,068.2	15,410,560	6.641
Wisconsin	9,892.2	1,784,726.0	1,794,618.2	33,216,581.8	35,011,200	5.126
Wyoming	29,460,919.0	641,464.4	30,102,383.4	32,240,656.6	62,343,040	48.285
Total	706,436,340.7	54,864,572.5	761,300,913.2	1,510,042,446.8	2,271,343,360	33.518

[1] Does not include Inland water.
[2] Excludes trust properties.

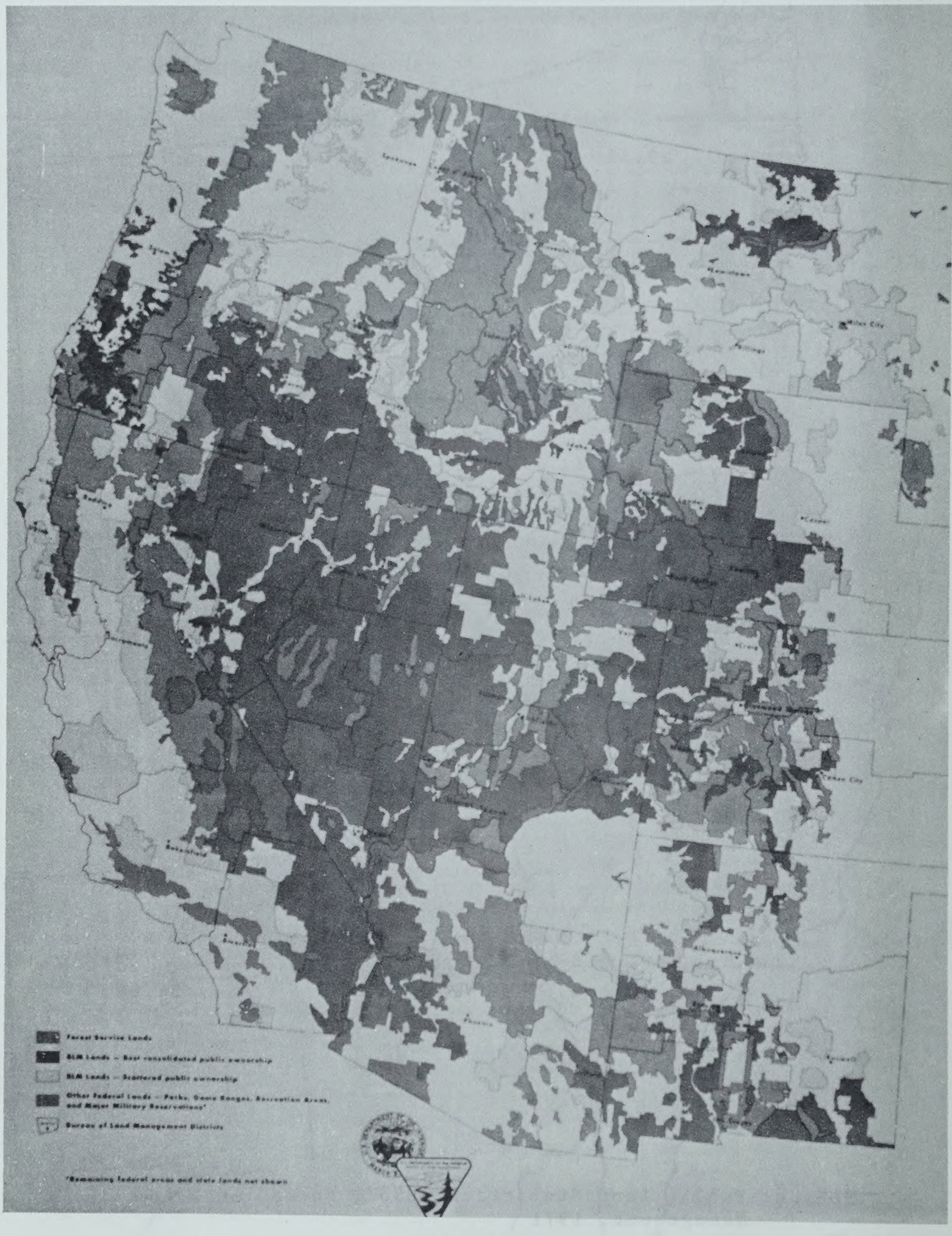
Source: Inventory Report on Real Property Owned by the United States Throughout the World, published by General Services Administration.

Figure II-16. Percentage of Federally Owned Land Within Each State



Source: Public Land Statistics, USDI, Bureau of Land Management, 1971

Figure II-16a. **MAJOR FEDERAL PUBLIC LAND AREAS IN THE WESTERN UNITED STATES**



wildlife habitat, and outdoor recreation. These lands include important open space and watersheds. Lands subject to leasing do not include towns or cities and generally are not the sites of significant industrial or commercial developments.

The public lands in these western states are not all characterized as vast, wild or semideveloped expanses. In many instances, public lands are scattered in relatively small tracts among largely privately owned lands. Such small tracts of relatively undeveloped Federal land, may best be managed consistent with, or in support of, surrounding land uses.

Public lands in the western states, many of which may have potential for geothermal development, have very diverse environmental characteristics which do not lend themselves to a detailed description in this general statement. A detailed description of the environment will be included in a portion of the environmental evaluation or impact statement as required for each new leasing area prior to leasing for geothermal development. However, a discussion of broad ecological relationships of geothermal leasing to broad biological communities, or biomes, of the western states can be of value in establishing the general setting within which more site sensitive environmental evaluations will be made.

Biomes are major biotic communities; that is, natural groups of organisms characterized by the occurrence of certain plants and animals which are "dominant" and "influent." International Biome Programs (IBP) have been initiated to analyze basic ecosystems, and among other goals to establish a scientific base for programs to maintain or improve environmental quality. Sharp demarcation lines between biomes have not been developed. Therefore, to utilize the basic advantages of the biome approach and to collect, analyze and recommend on the numerous potential effects of the action of geothermal leasing, organizational biome boundaries which include both aquatic and terrestrial communities are generally identified in Figure II-17.

It must be recognized that within each of the general biomes, biological "islands" or overlapping characteristics of the other biomes may, and often do, occur due to geographical, climatic, altitudinal and other variations. In these islands, the descriptions and impacts covered in the other general biomes may be applicable. These will be recognized in subsequent individual environmental analyses made for future proposed leasing actions in those specific areas where significant impacts may occur. Appropriate detailed treatment will be given at that time.

The 1973 Department of the Interior edition of Threatened Wildlife indicates that approximately 31 fish species, 10 reptile and amphibious species, 21 bird species and 17 mammal species, excluding marine mollusks that are listed as threatened, could directly or indirectly be impacted. In addition, there are an estimated 65 peripheral species and 69 species whose status is presently undetermined that could be impacted. Wherever threatened species may be involved, specific attention must be given to assure that geothermal leasing will not result in unacceptable adverse impacts on such species.

Biome Boundaries

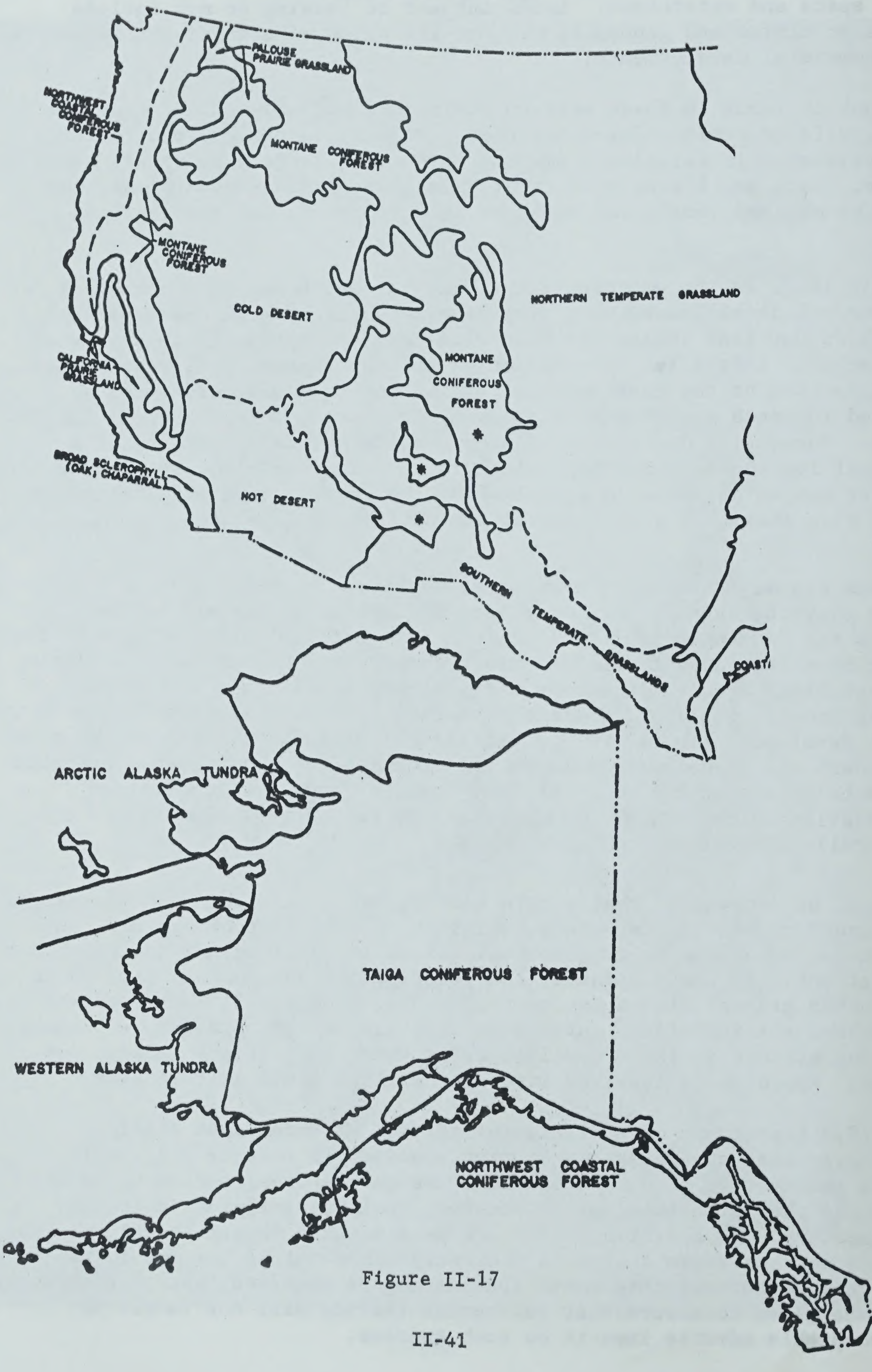


Figure II-17

Various States have their own flora and fauna listing for species they consider threatened within their boundaries. These may differ from the national listing so close coordination with State officials will be required to assure that adequate protective measures are taken.

Since these species of wildlife involve special consideration by local areas within biomes or various biomes and grouping of biomes associated with their total life cycle, they will not be discussed individually in this general environmental section. Instead, they will be given appropriate treatment and consideration within the evaluation process for each proposed leasing action.

Overview of the Western Biomes Under Consideration: 1/

1. Grasslands Biome. Grasslands occur where precipitation is too low to support the forest life zone, but is higher than that which results in desert life forms. Soils are highly characteristic and contain large amounts of humus. Larger grazing animals are dominant, and a large proportion of the mammals are running or burrowing types. Much of the grassland has been converted to agricultural cropland and domestic livestock grazing uses. Generally, the percent of Federal ownership of sub-surface mineral resources in this biome is limited because of historical land disposition actions which included the mineral estate.

2. Desert Biome. Deserts are shrub-vegetated ecosystems generally occurring in regions with less than 10 inches of annual precipitation and having heavy extremes of weather patterns. The vegetation is adapted to aridity, and bare earth is a conspicuous feature with little humus being formed. Deserts that are generally warm throughout the year, and very hot in summer, are called hot deserts; while those which become very cold in winter are called cold deserts. Animals are adjusted physiologically or in habits of life to tolerate the arid environment. Most of the area remains in native state and primarily is used for livestock grazing and increasingly for recreation.

3. Woodland-Bushland Biome. Woodland-bushland communities generally occur as biological islands at higher elevations in the desert and grassland biomes or in ecotones (transitional zones) between larger biomes such as the desert or grassland to coniferous forest transitions. Vegetative cover ranges from shrub species typical in the cold desert to brush and small tree species as precipitation generally increases with elevation. However, there is a diversity of species and climatic conditions between the subregions of this biome. Animal populations are equally diverse, ranging from numerous small reptilian species, rodents and small predators, to larger browsing mammals with a comparable range of bird species, the most evident being the soaring predators and scavengers.

The proportion of Federally managed land and subsurface resources is generally high throughout the woodland-bushland biome.

1/ Extensive use was made of a wide range of references to develop this broad biome presentation. A listing of such sources is included at the end of this section

4. Coniferous Forest Biome. The coniferous forests represent a diversity of environments, species compositions, soils, resource products and land uses under greatly varying climatic conditions. Essentially in high precipitation areas with a great capacity for vegetative growth, the coniferous forests are used primarily for wood and water production. However, high recreation values are bringing recreation to the forest as an increasingly important use, and suburban encroachment is growing in forest areas adjoining population centers.

5. Tundra Biome. The tundra community encompasses all of the treeless area in Alaska north of the Brooks Range and also extends along the Seward Peninsula into the Aleutian Chain. Its vegetation consists primarily of low grasses, sedges, lichens and mosses. Precipitation is low, occurring mostly as snow. Low to extremely low temperatures prevail, leaving a brief growing season. Many warm blooded animals remain active despite the climatic rigors. Permafrost is a dominant soil condition, and only a few surface inches thaw during the brief summers. This ecosystem is extremely fragile and subject to severe reactions to normally minor disturbances.

Virtually all of the tundra biome in Alaska is in Federal ownership. However, state land selection, especially in oil reserve areas are an exception, and native claims will undoubtedly take more land from Federal ownership, especially near coastal native communities. Oil and gas reserves are large in this region and exploration has been intensive during recent years.

Detailed Descriptions of Environmental Factors by Biomes

Introduction

The presentation generally is organized as follows:

- Ecological Interrelationships (Nutrient Cycle, Energy Flow, Hydrologic Cycle)
- Non-Living Components (Geology, Land Forms, Topography, Soils, Water, Air and Climate)
- Living Components (Vegetation, Animal, Human)
- Land Uses
- Aesthetics
- Other Considerations

Discussion of basic ecological interrelationships for each biome broadly sets the stage for consideration of the basic interacting environmental components both nonliving and living. Because it is impact on the quality

of the human environment that is to be evaluated, man's land uses, aesthetic values and other human scientific, educational and cultural values found within the environment are inventoried.

Ecological Interrelationships - A General Definition of Terms:

Ecological interrelationships deal with interworkings between and among all living and nonliving components of an ecosystem. The term ecosystem is used when referring to habitat and community as an interacting unit.

The functions of an ecosystem are dependent upon the primary producers that convert solar energy to chemical energy. Plants generally are the primary producers which convert solar energy, moisture, and the basic elements into organic energy. The consumers--cattle, deer, etc.,-- use the plants and they, in turn, are utilized by man and predators (wolves, skunks, etc.). The decomposers are primarily bacteria and other organisms that break down detritus material which are recycled through the system.

It is necessary to evaluate ecosystem modification on the basis of both structure and function of the system on a sustained basis, and impacts of geothermal leasing activities which may alter the functions of the ecosystem.

This presentation identifies unique differences between the biomes relative to animals, plants, soils and the water resource recognizing that much is yet to be derived as to the true impacts of disturbance or pollutant activities on aquatic and terrestrial communities. Subsequent analysis should recognize the need for continually improving knowledge on these matters.

The ecosystem approach attempts to consider the plant and animal communities and populations as a whole in relation to one another and to their total environment. The major component subsystems are the nutrient cycle, energy flow and the water (or hydrologic) cycle.)

Nutrient Cycles. Certain chemicals such as nitrogen, oxygen, phosphorous and potassium are essential elements to sustain life on the planet earth. These nutrients, as well as others, continuously circulate through the environment following fixed patterns or cycles and in the process are made available in various forms to man and animals (consumers). For example, nitrogen is recycled from plants (producers) to the atmosphere and back in a complicated process whereby organic material is converted into inorganic ammonia, nitrites, and nitrate by successive armies of microorganisms (decomposers). The nitrate, if not looped back through plants or stored in the soil, is then denitrified, and the nitrogen is returned to the atmosphere as gas where it again is available to nitrogen fixing plants, thus, completing the cycle.

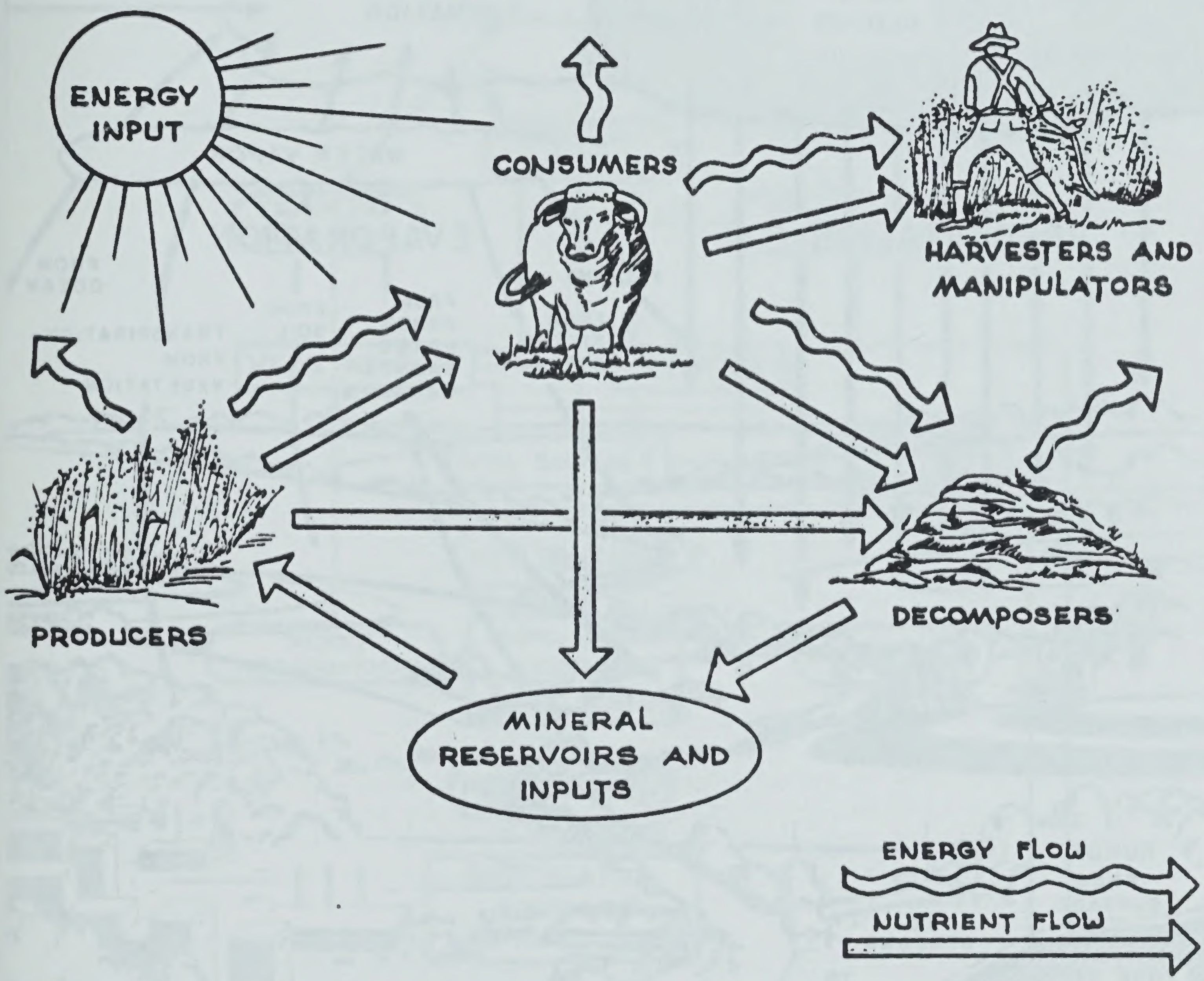
Under natural conditions nutrient cycles are more or less in balance. By contrast, man's use of the land for agriculture removes nutrients in the form of crops, thereby disturbing the natural balance which he then restores by the use of fertilizer. Disturbance or manipulation of a cycle involving a vital element, could disturb it beyond its compensatory powers resulting in its partial or even complete collapse.

Energy Flow. Energy flows through the ecosystem; it does not cycle. The components of the energy flow consist generally of abiotic inputs, producers, consumers, and decomposers as shown in figure II-18. For example, grasses (producers) capture energy from the sun by photosynthesis and utilize soil nutrients, water, etc. to produce vegetation. Herbivorous and carnivorous animals (consumers) feed on plants and other animals to acquire energy. Bacteria, fungi, and some kinds of animals (decomposers) derive energy in the process of decomposition of dead organisms. Energy is continuously being utilized (used by each group of organisms or lost) and new energy is being acquired from solar radiation.

Hydrologic Cycle. The hydrologic cycle is depicted in Figure II-19 The sun supplies the heat energy and this, together with the force of gravity, keeps the water moving from the earth to the atmosphere as evaporation and transpiration, and from the atmosphere to the earth as condensation and precipitation. Stream-flow and ground water movement complete the cycle. While there is no identifiable point of beginning or end, the oceans generally are considered to be the major source, the atmosphere as the transportation vehicle, and the land as the user. Within the total system there is no water lost or gained, but the amount available for use may fluctuate widely seasonally and geographically with supplies ranging from too much to too little. Water quality impacts resulting from man's use of lands, natural resources, and water supplies complicate problems of maintaining balance with man's needs within the capabilities and limitations of this natural system.

Of the many factors which contribute to the physical environment of an ecosystem, the movement of water into, through, and eventually out of the system is a major stimulus in the functioning of the system. This cycling of water in the ecosystem essentially consists of precipitation inputs, runoff outputs, and a series of intermediate processes influencing the magnitude of the precipitation/runoff relationship. These include interception, infiltration, percolation, evapotranspiration, surface runoff and storage at various levels of the system. The hydrologic cycle may be combined into a conceptual model of watershed behavior as shown in Figure II-20.

Figure II-18. A schematic Illustration of Pathways of Flow of Energy and Matter Through a Terrestrial Ecosystem



Source: Van Dyne, G.M. 1969. "Some Mathematical Models of Grassland Ecosystems," P. 6, in R.L.Dix and R.G.Beidleman (ed.), "The Grassland Ecosystem: A Preliminary synthesis." Range Science Department, Science Series No. 2, Colorado State University, Fort Collins, Colorado.

Figure II-19. Hydrologic Cycle

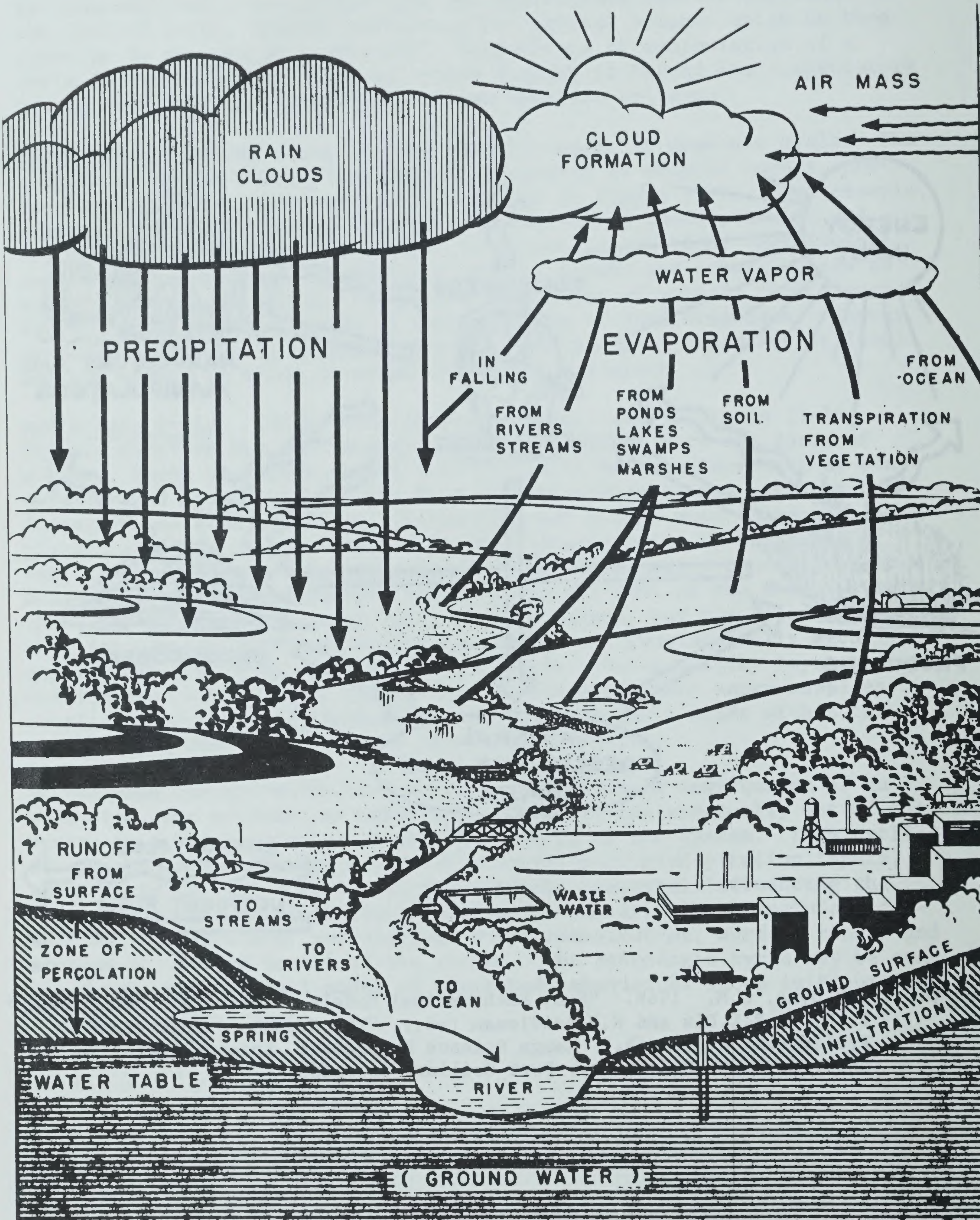
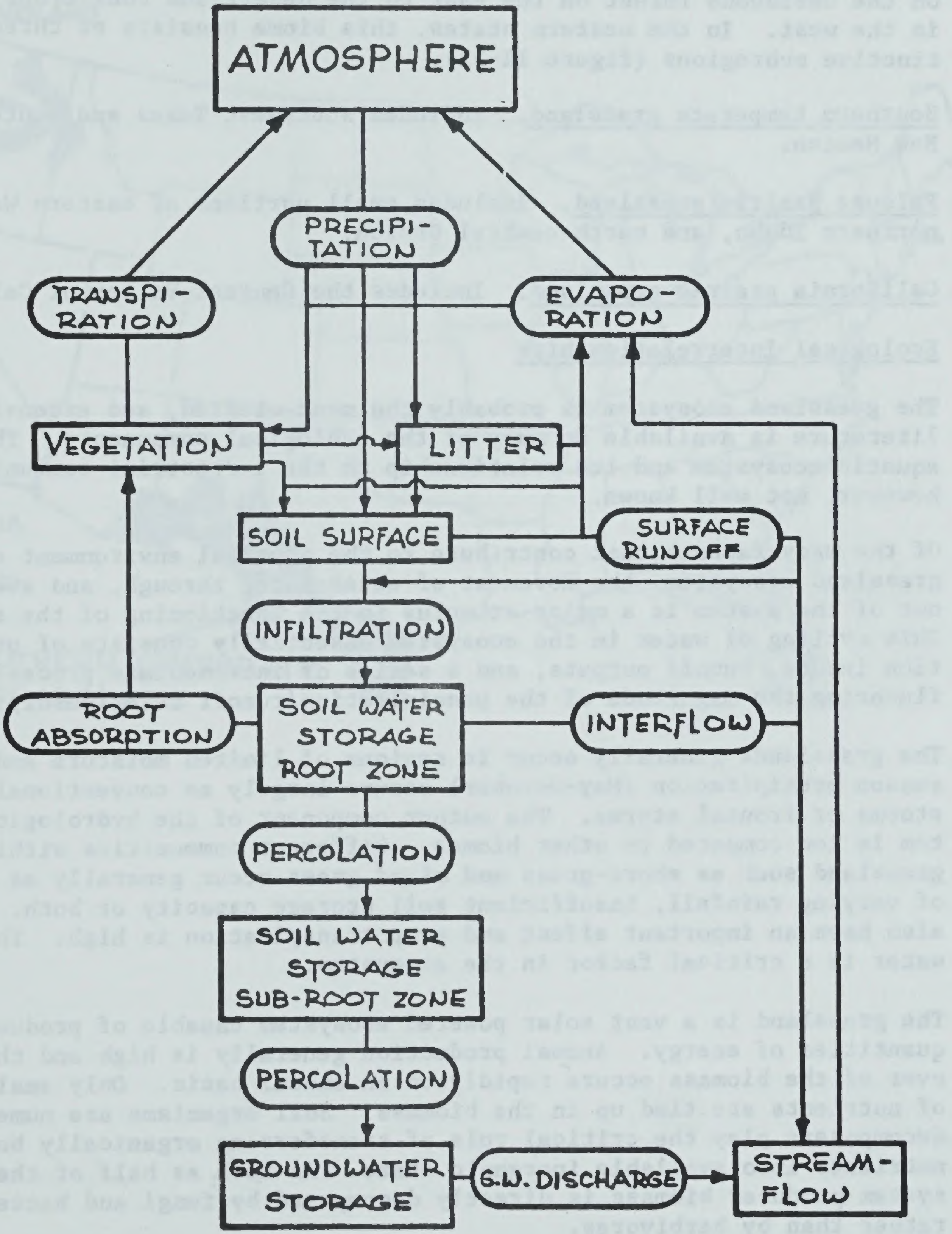


Figure II-20. Flow Diagram of the Grassland Hydrologic Cycle



Source: Striffler, W.D. 1969. "The Grassland Hydrologic Cycle," p. 103, in R.L.Dix and R.G.Beidleman (ed.), "The Grassland Ecosystem: A Preliminary Synthesis." Range Science Department, Science Series No. 2. Colorado State University, Fort Collins, Colorado.

Detailed Discussion of Biomes

1. Grassland Biome

This biome is the most extensive and varied of all the biomes fringing on the deciduous forest on the east to the desert and coniferous forest in the west. In the western states, this biome consists of three distinctive subregions (figure II-21).

Southern temperate grassland. Includes southwest Texas and southern New Mexico.

Palouse prairie grassland. Includes small portions of eastern Washington, northern Idaho, and north-central Oregon.

California prairie grassland. Includes the Central Valley of California

Ecological Interrelationships

The grassland ecosystem is probably the most studied, and extensive literature is available on many of the ecological components. The aquatic ecosystem and its relationship to the terrestrial community is, however, not well known.

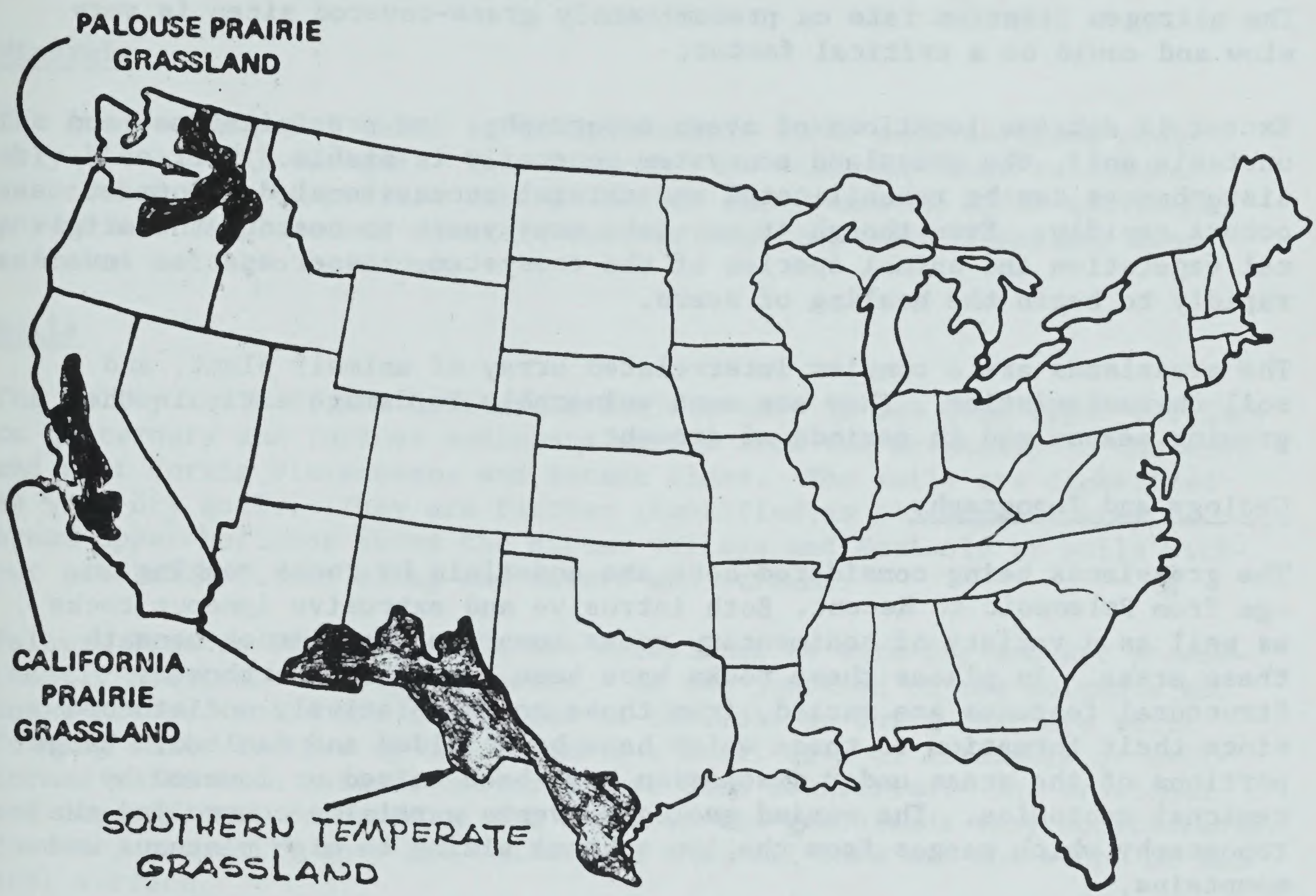
Of the many factors that contribute to the physical environment of the grassland ecosystem, the movement of water into, through, and eventually out of the system is a major stimulus in the functioning of the system. This cycling of water in the ecosystem essentially consists of precipitation inputs, runoff outputs, and a series of intermediate processes influencing the magnitude of the precipitation/runoff relationship.

The grasslands generally occur in regions of limited moisture and growing-season precipitation (May-October) occurs largely as conventional thunderstorms or frontal storms. The output component of the hydrological system is low compared to other biomes. Different communities within the grassland such as short-grass and mixed grass occur generally as a result of varying rainfall, insufficient soil storage capacity or both. Winds also have an important effect and evapotranspiration is high. Thus, water is a critical factor in the ecosystem.

The grassland is a vast solar powered ecosystem capable of producing great quantities of energy. Annual production generally is high and the turnover of the biomass occurs rapidly on an annual basis. Only small amounts of nutrients are tied up in the biomass. Soil organisms are numerous and decomposers play the critical role of transferring organically bound nutrients into available inorganic state. As much as half of the ecosystem producer biomass is directly decomposed by fungi and bacteria rather than by herbivores.

In the grassland biome, nitrogen and phosphorous are the two important nutrients provided by vegetation to support other life forms. Unconsumed

Figure II-21. Grassland Biome



nutrients are recycled through the soil in a short time period because of annual mortality or dieback of grass species. This contrasts with slower cyclic biomes such as the forest biome where a large share of the nutrients are stored in trees having a natural life span of hundreds of years. The nitrogen fixation rate on predominantly grass-covered sites is very slow and could be a critical factor.

Except in extreme locations of steep topography, low precipitation, and unstable soil, the grassland ecosystem generally is stable. Surface disturbances can be rehabilitated and natural successional development occurs rapidly. Even though it may take many years to restore the original vegetation and animal species of the ecosystem, lesser species invade rapidly to begin the healing of scars.

The grasslands are a complex interrelated array of animal, plant, and soil characteristics. They are most vulnerable to damage early in the growing season and in periods of drought.

Geology and Topography

The grasslands being considered here are underlain by rocks ranging in age from Paleozoic to Recent. Both intrusive and extrusive igneous rocks as well as a variety of sedimentary rocks comprise the bedrock beneath these areas. In places these rocks have been highly metamorphosed. Structural features are varied, from those rocks relatively undisturbed since their formation to those which have been folded and faulted. Large portions of the areas under discussion have been raised or lowered by regional tectonics. The varied geologic events partially controlled the topography which ranges from the low coastal plains to high plateaus and mountains.

The California Prairie (also called the San Joaquin Valley) is approximately 400 miles long and 50 miles wide. The long axis of the valley is a geologic syncline or low that parallels the coast. The main drainages in the valley are located along this same structural axis. It is essentially flat with little relief between the river bottoms and the uplands. The low relief hills between the rivers are well rounded with few sharp features or escarpments. The valley is flanked by major normal and thrust faults, and there are inferred faults in the valley itself. The focus of the Arvin-Tehachapi earthquake of 1952, magnitude 7.5, was beneath the San Joaquin Valley.

The Palouse Prairie lies east of the Cascades and includes all or portions of the Walla Walla Plateau, Blue-Wallowa Mountains, and other portions of the High Lava Plains which are a part of the Columbia Plateau. The main structural features in the southern portion are broad anticlines which are predominantly oriented east-west and some are accompanied by similar trending faults. There have been no major earthquake epicenters located within the region since 1905. Surface rock outcrops are predominantly volcanics of Tertiary age; however, some Mesozoic age sedimentary and igneous rocks occur in the southern and northern portions of the area.

The topography of the Palouse Prairie varies from plateaus underlain by flat lying lavas to the mountains which are in part controlled by folds and faults. Valleys or canyons have been incised into the bedrocks by tributaries of the Columbia River.

Minerals

The greatest mineral value in the grasslands under consideration probably lies in oil and gas. Lesser amounts of coal and those substances associated with evaporites such as sodium and potassium offer additional potential. Replacement minerals such as uranium, iron, vanadium, lead, and zinc may also be found.

Soils

The valley soils of the California Prairie vary in age from Upper Tertiary to Quaternary and include sediments eroded from the mountains to the east and west during Pleistocene and Recent times. The soils are classified as warm-dry soils. They are further identified as Alfisols or grey to brown upper horizons above the stream valleys and Entisols or soils without natural horizons along the rivers and streams.

Palouse Prairie Province soils are classified as warm-dry and are predominantly Mollisols or organic soils. At the junction of the Columbia and Snake Rivers, soils are identified as Entisols or soils that are still forming while further up the Columbia a small area of Aridisols or well-formed soils with natural horizons have been identified. The erosional and depositional features of the soils in the grasslands vary considerably. However, generally they are related to the soil base and the slope of the soil surface.

Water

The major water supplies of the grassland biome are provided by the through-flowing rivers and streams of major drainage basins which receive most of their water from the higher elevations above the grassland areas. The relatively lower grasslands receive about 8 to 24 inches of precipitation annually with the coastal prairie areas receiving up to 40 to 60 inches per year. Many of the smaller streams within the more arid grasslands are ephemeral rather than perennial. The quality of both surface and ground waters varies from area to area within the biome.

Surface Water. Surface water resources within the grasslands include streams, rivers, reservoirs, lakes, marshes, potholes, and springs. These sources are utilized for such uses as domestic, municipal, industrial, power, agricultural, recreation, and fish and wildlife purposes.

Except for the higher precipitation zones, annual runoff from the grassland generally is low. The quality of water in most rivers, streams, lakes, and springs generally is adequate. Average dissolved solids

(ions of sodium, calcium, etc.) vary from less than 100 ppm to more than 2,000 ppm while average sediment concentrations in streamflow may vary less than 280 ppm to more than 30,000 ppm.

<u>Ground Water</u>. Ground water supplies vary within the grassland areas with some areas having large quantities of ground water.

The quality of ground water varies from area to area with a dissolved solid content ranging from less than 1,000 ppm to more than 10,000 ppm.

<u>Climate and Air</u>

The climatic conditions within the grassland biome differ significantly depending on the location of each specific grassland area within the United States. For this report, climate is defined as the combination of precipitation, temperature, and wind. The distribution of these quantities is shown by a series of maps developed from the long-term climatic records.

Because the grassland biome is not uniform in the distribution of climatological parameters, each western grassland area is discussed separately.

<u>The Palouse Prairie</u> is generally influenced by the continental air mass with some modification from the Pacific Ocean. Consequently, this area has milder climate than northern plain states directly to the east at the same latitude.

The average annual precipitation varies from 10 to 15 inches. Most precipitation falls in the winter months. Thunderstorms occur about 10 days out of the year. Temperatures reach extremes of 30° below zero to 110° above. However, the mean daily temperature varies from 25° to 30° in January to 70° in July.

Winds are generally from the south in both the winter and summer and, while averaging 8 mph, may gust strongly at times. Dust storms may occur in the summer months when the light surface soil is dry. There are about 10 to 20 days of dense fog with the maximum frequency of occurrence during October.

<u>The California Prairie</u> is greatly influenced from the Pacific Ocean to the west. The average annual precipitation varies from 6 inches in the south to 23 inches in the central part of the grassland. Most precipitation occurs during the winter months with virtually none falling during the summer. Thunderstorms occur during the winter months with the passage of cold fronts.

Temperatures range from a minimum of 15° to a maximum of 115° with mean daily temperatures varying from 40° in January to 80° in July. Winters are mild throughout the area while summers are hot.

Winds are generally from the south during the winter months, except when storms move through the area when they tend to blow from the northwest. During the summer months the wind is generally out of the west. Winds are often much stronger (30 mph or more) than the 3 mph average indicates. There are from 15 to 25 days of dense fog each year during the winter months as temperature inversions keep the moist Pacific air trapped within the valley basin.

<u>The Southern Temperate Grasslands</u> climate is influenced by the continental air mass to the north and the humid Gulf to the southeast.

The average annual precipitation varies from 10 inches in the northwest to 40 inches in the southeast. Temperatures may range from 10° below zero to 110° above; mean daily temperatures vary from 35° in January to 75° in July in the northwest and from 60° in January to 80° in July in the southeast. Winds generally are variable and light in the winter months; during the summer they tend to blow from the southeast, bringing moist warm air from the Gulf. Dense fog occurs about 5 to 10 days each year. Humidity is lower in the west and higher in the southeast.

<u>Vegetation</u>

The predominant vegetation of the grassland biome consists of a large selection of grass species occurring in both a natural state and in areas under cultivation. Species of woody plants do exist. Historically as well as presently many of the native and introduced grass species provide crops for man's consumptive use as well as forage for domestic and wild animals. Together they represent the relatively intensive use often being made of the vegetation growing on grassland areas. The grazing of cattle and sheep often has been one of the major contributors to plant succession, particularly in increasing the distribution of woody plants and forbs and in some instances the creation of desert-like conditions. In addition to serving as an important food source, the grass species act as a soil stabilant in minimizing water and wind erosion, thus representing a multi-value resource.

In general the grasslands are located where there is not sufficient rainfall to support forest-like vegetation but enough moisture to preclude the formation of a desert-type biome. Within its borders are marshes, lakes, ponds, and other water courses which support various forms of aquatic vegetation.

The terrestrial vegetation of the grasslands varies somewhat with its geographic location and can best be described on a specific grassland area basis.

The Southern Temperature Grassland represents the driest of the areas in the grassland biome. Consequently, parts of it are dotted with desert shrubs due to the dry subtropical climate and, in some cases, overgrazing.

The Palouse Prairie consists of mid-grass species; however, extensive areas have been replaced by sagebrush as a result of fire and overgrazing. Within its borders is the wheat-producing region known as the Palouse.

The California Prairie consists of mid-grasses of the bunch life type, similar in form to those of the Palouse. These native grasses have been largely destroyed by overgrazing and fire and replaced by annual grasses introduced from Europe. Extending north and south along the major drainages are the tule marshes, parts of which have been converted to rice production.

Animals

The generally high annual turnover of new-primary-production in most grassland communities provides a food base for support of both large numbers and varieties of animals. As one might expect, many species are "grazers," many are burrowers," and a large number of birds are ground nesters. Large herbivores are a characteristic, if not common, feature. Insect life is abundant and varied and is heavily utilized as food by many secondary consumers. Soils tend to be well developed, and correspondingly so, the soil, fauna, and flora, including both macro- and micro-organisms, represent every major animal phylum as well as many taxonomic groups in the plant kingdom. Many of the animals (e.g., antelope, rodents, various birds and insects, etc.) are gregarious in behavior and frequently occur in large concentrations.

Grassland communities are subject to drought periodically and therefore the populations of some wild animal species can fluctuate widely in numbers from year to year. Additionally, a most important exotic component of grassland "fauna" are the large domestic herbivores (e.g., horses, cows, sheep, goats) which have largely replaced the native wild forms. Livestock grazing greatly influences grassland ecosystems.

The following discussion of grassland animal life considers wild and domestic groups separately. Wildlife is grouped as terrestrial or aquatic. Soil organisms are briefly treated here.

Characteristic animals of the Southern Temperate grassland include antelope, jack rabbit, cottontail rabbit, prairie dog, ground squirrel, coyote, badger, ferret, pocket gopher, various waterfowl, collared peccary, scaled quail, white-winged dove, mockingbird, prairie chicken, sage grouse, Swainsons hawk, rough-legged and ferruginous hawks, burrowing owl, many ground nesting birds such as the meadowlark and horned lark, bullsnake, rattlesnake, kingsnake, numerous kinds of lizards, grasshoppers, crickets, and an abundance of other insects.

On the Palouse Prairie, the sharp-tailed grouse was formerly abundant. The short-eared owl, burrowing owl, and marsh hawk nest in the grassland. Cottontail and pygmy rabbit, pocket gopher, and goldenmantled ground squirrel and various grasshoppers are characteristically present.

On the California Prairie, the California ground squirrel is one of the most characteristic species. This is an important wintering area for waterfowl. Many of the same animals, perhaps of different subspecies, occur here as in other grassland areas.

Some grassland species will require special consideration within their ranges. For example, a local population may require a specific site at a particular season to continue its life cycle, such as strutting grounds for sharptail, sage grouse or pririe chickens; potholes , reservoirs or marshes by waterfowl and shore birds for nesting and rearing young. Other species extend their distribution into subtypes and local populations become totally dependent upon such restricted habitat. Somewhat comparable are remnant populations of a species which, while not endangered throughout its range, is locally threatened with extirpation; for example, the sharptail grouse in the Palouse grassland.

Aquatic. This includes various vertebrates such as fish, frogs, snakes and invertebrates such as crustacea, mollusks, and insects that are dependent on a water environment. The aquatic fauna of this biome in general is less diversified than some of the other biomes. Fish population, natural and introduced, varies in respect to type of water, surface of body and water quality. Fish populations can generally be broken down into sport, commercial, forage, and undesirable species.

Threatened or Endangered Wildlife. Several threatened and endangered species of wildlife are characteristic of the grasslands. Examples include the prairie falcon, American peregrine falcon, tule elk, San Joaquin kit fox, and blunt-nosed leopard lizard

Domestic Livestock. Historically, grasslands have been grazing lands and were the native habitat of the large herbivores prior to settlement by white man. During the period of early settlement these lands were used almost exclusively for grazing. Today, beef, lamb and wool are the principal products of those portions that have not been converted to other agricultural production. Some horses and goats also are grazed, but this is a minor use.

In general, beef cattle production is the most important domestic livestock use of the grassland biome for the reason that cattle are better adapted than sheep to the type of forage produced.

Soil Organisms. Small forms of animal life which spend their entire lives in the soil (as earthworms) or depend upon it for a part of the life cycle (as many insects) play a vital role in soil building. They also are extremely important items in the food-chain of larger animals. Micro-organisms are essential for soil building processes of organic decay. Members of the soil fauna comprise major components in the detritus food web and, hence, they play very significant roles, either directly or indirectly, in the pattern and dynamics of energy flow and biogeochemical cycling of grasslands.

Human Settlement and Use Characteristics

Population characteristics of the grassland biome exhibit extreme variability. Rural and undeveloped lands of a natural character make up the majority of the biome; however, the area also includes several communities with significant differences in population densities, economies, and social environments.

Low population densities and other characteristics of these rural-natural lands reflect economies and employment that are geared to resource production and primary processing. Agriculture and agricultural processing are principal economic activities. Mineral extraction and processing tends to be localized.

The recreation-tourism industry has grown rapidly the past 20 years, providing employment in the services sector of the economy. Small towns and villages are scattered through the natural-rural area of the biome. The larger of these settlements (5,000 to 10,000 population) are market centers and generally are located along transportation arterials. Extensive uses of the land for ranching, farming, and mining have a relatively low employment demand reflected in low population densities. The economic and social environment tends to resemble a "frontier" economy. Economic and cultural disadvantages may be offset by a relatively high quality natural environment, a slow pace of life, and ready access to large areas of open space.

Urbanized areas in the western portion are in close proximity to extensive public lands. Significant western metropolitan areas include: Great Falls and Billings, Montana; Boulder, Denver, Colorado Springs, and Pueblo, Colorado; Spokane, Washington; and the extensive Central Valley metropolitan complex within the California portion of the biome. If present trends continue, the prediction of an urban megalopolis stretching from Cheyenne, Wyoming, to Pueblo, Colorado, may become fact by the end of the century.

Land Uses

The Homestead Act of 1862, railroad construction, irrigation, and other factors successfully encouraged cultivation of vast areas of grassland biome. Areas remaining in a "natural" condition were typically unsuited

for agriculture and may be in either private or public ownership. Extensive livestock grazing occurs on these "natural" lands throughout the biome. Extensive recreational uses such as hunting, fishing, hiking, and off-road vehicle use occur also on this category of land, particularly on those tracts that remain in public ownership.

The California Central Valley portion of the biome contains extremely productive irrigated agricultural land. Production of nuts, fruits, vegetables, rice and specialty crops are important. Extensive livestock grazing occurs on undeveloped areas, as does recreational uses. Recreation is particularly significant because of the close proximity of large metropolitan areas.

Wheat grown by dry farming methods is the major agricultural use in the Palouse Prairie segment of the biome. Significant western portions have been irrigated; drier, unirrigable portions remain undeveloped and are used for grazing.

The metropolitan areas within the biome are growing rapidly, imposing a demand for residential, commercial and industrial expansion areas. Smaller towns and villages may also require areas for growth, depending on local economic conditions. In nearly all cases, population concentrations place a demand on adjacent rural or natural lands for open space to provide recreational uses such as hunting, fishing and pleasure driving by on and offroad vechicles.

Mineral extraction is concentrated primarily in oil and gas production in the southern portion of the California Central Valley.

Aesthetic Values

The form of the grassland may be described as primarily gently rolling hills and broad expanses of relatively flat lands. In some areas near major streams, particularly in drier portions of the biome, continuity of the land form may be interrupted by sharp breaks down to floodplains of the stream. Because of the relatively gentle slopes in the grasslands, most of man's activities seldom interrupt continuity of the form. Where the form is disturbed it is usually easily restored to a natural or near natural condition. Where the landscape is still in a natural state, the texture is the soft texture of the grass covered slopes interrupted by occasional rock outcrops. In drier portions, ground cover may be scattered patches with a good deal of exposed soil. Much of the Palouse Prairie and the California Prairie has been converted to agriculture. Here the texture changes from field to field as the crops change.

Lines in natural portions of the biome play a minor role in the landscape and are evident only in ridgelines and in the occasional road or powerline crossing through the area. In the agricultural areas, lines become much more obvious. Crop rows, field edges, fence lines, and roads become a dominant element in the landscape.

Color is a key factor in the aesthetics of grassland biome. The seasonal changing pattern in the cultivated areas of freshly-turned black soils to lush greens of early summer to the golds of fall are striking. In the natural and drier areas the colors are generally more muted but can be beautiful in their sublety.

Scale is difficult to define on the flat plane of the grasslands. Any vertical element which is introduced into the landscape has a tendency to define the scale but also draws the eye and becomes a focal point.

The total effect of the landscape character of the grassland biome will vary with the individual observer. To one, openness may connotate a freedom, room for movement, a challenge to action. Another may feel overwhelmed, lonesome and unprotected. To some it may seem to be monotonous. To the acute observer subtle changes in tone or forms may be fascinating.

Geological Interest Values

Human interest in geological phenomenon tends to center around those features that are different and strange or beautiful and exciting. Things like volcanic necks, caves with stalagmite formations, sinks, natural arches and bridges, fossils, erosional features, etc. arouse the interest and curiosity of the viewer. The grasslands biome has some of these features but, being primarily a flat landscape, they are rather limited. The Southern Temperate Grassland contains, among other things, limestone caves in the Pecos River region and sinkholes near Roswell, New Mexico.

Archeological Values

Archeological sites of the three broad developmental stages of American Indian prehistory are found in the biome--the Paleo-Indian, the Archaic, and the Agriculture. Not all peoples reached the stage of agriculture nor did they all go through all stages to reach any other.

Both the Eastern Big-Game Hunting Tradition and the Western Old Cordilleran Tradition within the Paleo-Indian stage have been recognized within the biome. The Big-Game Hunting Tradition is recognized in kill sites of animals such as the bison, mammoth, camel, and horse. Less frequently campsites have been found with chipping and other camp debris. Some cave sites have been found. The Big-Game Tradition has been recognized in the Southern Temperate Grasslands.

The Old Cordilleran Tradition represents a relatively unspecialized hunting-gathering-fishing way of life. Evidence has been found in old lakeshore campsites, caves, and deeply stratified refuse dumps in favorite fishing spots. The tradition has been found in both the Palouse and California prairies.

The Archaic stage is found as a Plains Archaic Tradition in the Southern Temperate Grasslands. Hunting continued during this stage, but more emphasis was placed on gathering plants and some shellfish. In the Plains Archaic, this is indicated in the sometimes deep trash dumps, dry cave sites, burned rock debris mounds, and campsites. Bison and other animal-kill sites continue to be found, including some buffalo jumps with rock alignments.

The Desert Archaic tradition is found in the Southern Temperate Grasslands. It also contributed to the cultures found in the California prairie. The Desert Archaic subsistence pattern was based primarily on small seed gathering and small animal hunting. Archeological evidence is derived primarily from campsites, dry caves, petroglyphs, and pictographs.

For the most part, the third general stage of prehistoric development had cultures found by the first non-Indians to visit the new world.

Evidence of the Agricultural Pueblo Tradition is found in the northern portions of the Southern Temperate Grassland. Archeological evidence of the Pueblo Tradition, here represented by the Mogollon Division, includes sites of masonry buildings, pithouse dwellings, occasional irrigation systems, trans mounds associated with villages, pictographs, petroglyphs, caves, fortified sites, and roasting pits. Peoples who continued the Archaic stage of development up to the time of contact with non-Indians left remnants of their occupancy in the rest of the Southern Temperate Grassland.

In the Palouse prairie, agriculture was never developed by the native inhabitants to the final pre-contact periods are represented by the Northwest Riverine Tradition. These peoples lived along the river valleys, and their archeological sites are primarily the remains of pithouses and above ground houses in villages along the rivers, campsites, quarries, petroglyphs, and burial grounds.

The Agriculture stage did not develop in the California prairie; the Archaic stage continued up to the time of contact with non-Indians, as indicated by large shell mounds occurring near water, quarries, and village sites.

2. Desert Biome

The desert biome includes areas where precipitation and climatic conditions do not support either a grassland or a woodland-bushland biome. It is divided into two primary subtypes: cold deserts and hot deserts. The former have warm summers and cold winters while the latter range from moderately warm in winter to extremely hot in summer. These two types of desert are mapped geographically in figure II-22. Basically, the delineation is as follows:

Cold Desert. Extends through central Washington, through western Colorado and south to northeastern California, Nevada, Utah, and northern Arizona and New Mexico broken by grassland and woodland types as a result of elevation and precipitation variations. It is sometimes referred to as the High Desert, Great Basin Desert, or Painted Desert.

Hot Desert. Extends at lower elevations through southeastern California and the southern portions of Nevada, Utah, Arizona, and New Mexico. Sometimes it is referred to as the Mojave Desert, Lower Colorado River Desert, or Sonora Desert.

Direct Federal land ownership and control of subsurface minerals is high throughout this biome. Present oil and gas exploration activities are generally light throughout the biome with the exception of some areas in eastern Utah. Production of oil and gas from Federal lands is moderately havy along the eastern edge of the desert (Wyoming, Utah, Colorado, and New Mexico).

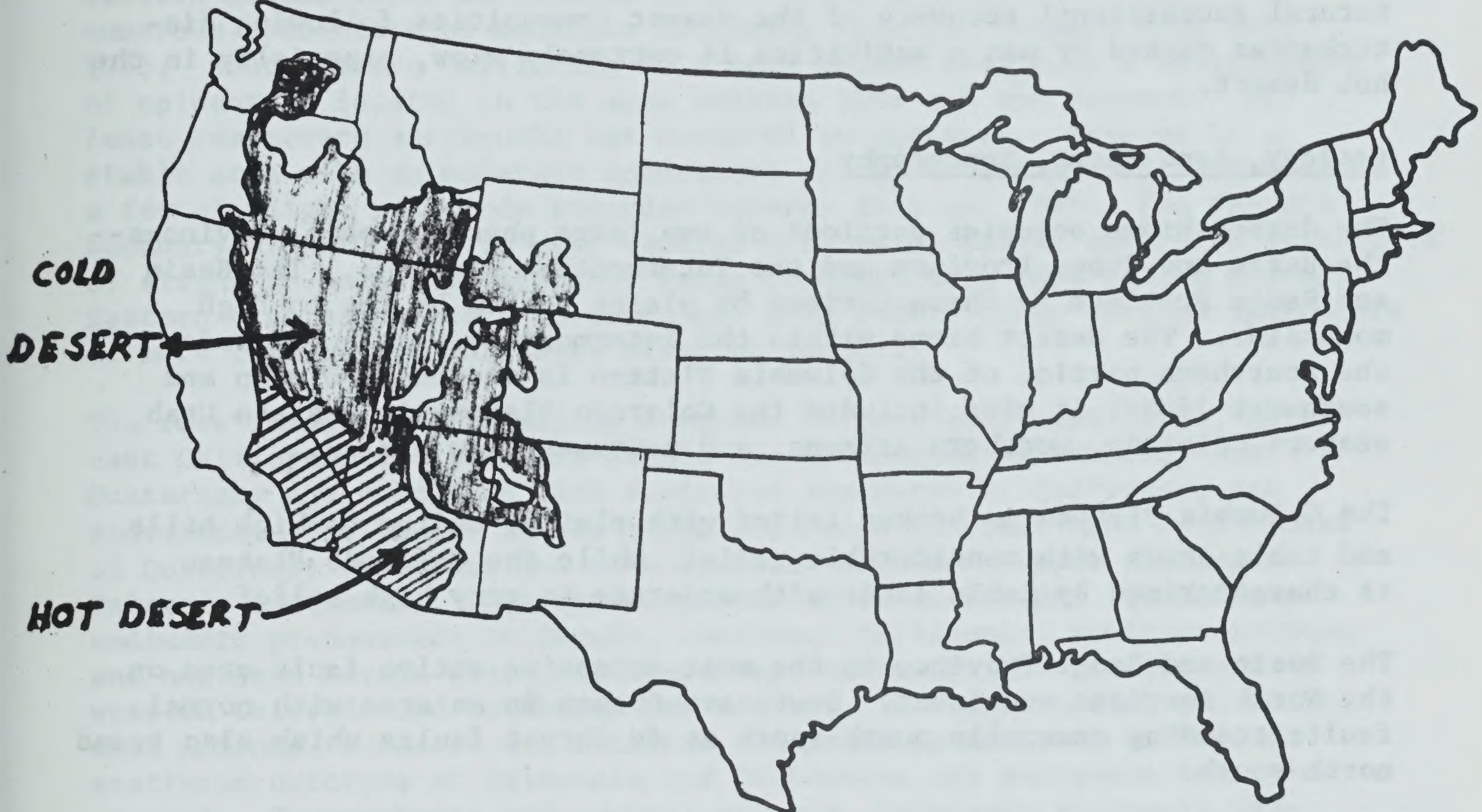
Ecological Interrelationships.

Desert ecosystems are exceptionally vulnerable to misuse and in many places are subject to rapid change. While there has been considerable descriptive literature and scientific studies of the desert, there is little known about the interrelationships or workings of the desert ecosystem. Additional study is needed, especially in view of the readily apparent delicate ecological balance which exists in desert ecosystems. For example, introduction of grazing animals has caused plant successions and other ecological changes along the borders of the desert which have extensively extended the desert ecosystem into previous grassland communities.

Hydrologic Cycle. In desert ecosystems, precipitation input is small with considerable variation from year to year. Evapotranspiration is great, particularly in the hot desert and southern portions of the cold desert areas. The net result is less available soil moisture in the southern latitudes of the desert areas which reduces the potential for production of the living components of the desert ecosystem.

Energy Flow. Solar radiation is high, but due to other climatic factors such as limited precipitation and sparse vegetative cover much less of this energy is captured by photosynthesis and greater amounts are stored in succulent vegetation. Therefore, the production capacity of the desert is greatly reduced and the food chain shortened.

Figure II-22. Desert Biome



Nutrient Cycle. The nutrient cycle occurs slowly in the desert with large quantities of nutrients tied up in the shrubby biomass and a slow rate of decomposition. Man's use of the desert has altered the balance of the nutrient cycle. Additional data is needed to fully understand this component of the ecosystem and analyze impacts.

Natural successional recovery of the desert communities following disturbances caused by man's activities is extremely slow, especially in the hot desert.

Geology, Land Forms, Topography

The desert biome occupies portions of two large physiographic provinces--the Basin and Range Province and the Intermontane Plateaus. The Basin and Range Province is characterized by plains broken by low to high mountains. The desert biome within the Intermontane Plateau includes the sourthern portion of the Columbia Plateau in southeast Oregon and southwest Idaho; it also includes the Colorado Plateau in Eastern Utah, western Colorado, northern Arizona, and northwest New Mexico.

The Columbia Plateau is broken relief with plains, medium to high hills and table lands with considerable relief, while the Colorado Plateau is characterized by table lands with moderate to very high relief.

The Basin and Range Province is the most extensive active fault area on the North American continent. Southeast Oregon is an area with normal faults trending generally north-south as do thrust faults which also trend north-south.

Nevada has an extensive fault system predominantly oriented north-south; however, both normal and reverse cross faults trending northeast-southwest are present. The same fault pattern of Nevada also occurs in western Utah where it forms the eastern boundary of the desert biome. In southeast California the fault pattern changes to become predominantly northwest-southeast oriented strike-slip faults, cross faulting is also common. The normal and reverse northwest-southeast trending faults in southern Arizona are probably a continuation of the extensive system of faulting that follows the Rio Grande along the Texas-Mexican border into southern New Mexico where the Rio Grande lies within a grabben or fault depression.

Many of the earthquake epicenters appear associated with the general fault trends within the Basin and Range Province; however, many of the known mapped faults appear to be inactive with no significant movement since late 1600 or for over 300 years. Southeastern Oregon has no known epicenters and southwestern Idaho has had no significant epicenters since 1920. In southeastern Idaho along the boundary of the desert biome, epicenters of minor significance were recorded between 1955 and

the present time; however, there have been no major epicenters located in this area. Northeastern California would also be considered a stable area with only one epicenter of moderate magnitude located in the area since 1890; this took place over 20 years ago.

Western Nevada would be considered an active area as there have been numerous epicenters of moderate intensity recorded between 1905 and 1955. Southeastern California is a very active area with a large number of epicenters located in the area between 1640 and the present. At least one severe earthquake has occurred in the area. Arizona is a stable area with no moderate epicenters of record since 1865, and only a few of slight magnitude recorded between 1955 and 1965. The eastern boundary of the biome in west central Utah is an active area with epicenters of slight to moderate intensity being recorded from 1890 to the present. Eastern Utah and western Colorado are both stable areas with no epicenters of more than slight intensity being of record.

The rock formations exposed in southern Oregon, southwest Idaho, northeast California and northern Nevada are predominantly Tertiary and Quaternary age volcanics with scattered exposures of Quaternary age sediments. The faults in the Basin and Range Province have left blocks of Quaternary sediments and with isolated blocks of Upper and Lower Palezoic sediments. This system predominates in Nevada. Quaternary sediments predominate in Nevada, southeast California, southern Arizona and northern Nevada while Cretaceous age sediments are predominant in western Colorado and northwest New Mexico. In southern Utah and northeast Arizona, Jurassic and Triassic sediments predominate with large scattered outcrops of Paleozoic and Cretaceous age sediments being present. In northwest and central Arizona, Paleozoic sediments predominate with several large exposures of Quaternary and Tertiary being present also.

Minerals

Mineral deposits, both leasables and locatables, are distributed throughout the desert biome. The leasables are principally of the evaporite type (salts) with the exception of sulfur which possibly was introduced as a result of the volcanic activity in the biome. The locatable mineral deposits are of fissure filling, injection, replacement, of disseminated emplacement types.

Both the leasable and locatable mineral deposits are found throughout the desert biome. The major areas of concentration appear to be in the areas of the major faulting and volcanic activity. These are in areas unlikely to produce oil and/or gas.

The evaporites are likely to be found where the downthrown block of a fault has exposed lower lying former lake beds, the drying up of which has resulted in the formation of bedded deposits of evaporites. Totally buried deposits also are present. The locatable minerals are likely to be found in areas of intensive igneous activity and considerable faulting.

The leasable minerals likely to be found in the desert biome are phosphate, sulfur, salt, potash and some borates. Ores of lithium, bromine, magnesite and brucite, which are sometimes leasable, also are found. Examples of the locatable minerals to be found are barite, fluorspar, manganese, molybdenum, vanadium, tin, tungsten, niobium, tantalum, gold, silver, copper, lead and iron.

Soils

The cold desert generally contains three soil orders. The dominant order is the Aridisols. The Aridisols occur in south central Idaho, southeastern Oregon, central Washington, Nevada, and western Utah. This order is very extensive and quite contiguous. Aridisols have prolonged dry periods each year and have light colored surface soils.

Mollisols are the second most extensive soils occurring in the cold desert. They occur in eastern Washington and Oregon, southeastern and southwestern Idaho, central and southwestern Utah, and northeastern California. The Mollisols associated with the cold desert have a prolonged dry period each year.

Entisols are young and essentially non-developed. Entisols are found in recent alluvium, recently stabilized sand dunes, or on steep slopes subjected to rapid soil creep. Areas of Entisols are located in south central Oregon, western Nevada and central Utah.

The soils of the hot desert biome belong in the Aridisol soil order. These soils are found in southeastern California, southern Nevada, southern Arizona and southwestern New Mexico and are hot, dry and low in fertility. Basically, the Aridisols contain two suborders known as (1) Orgids and (2) Orthids. Both of these suborders have a characteristic hardpan or duripan but differ in structure and composition as follows:

> The hardpan developed under the suborder Orgid consists of an accumulation of clays and the suborder Orthid is composed of an accumulation of calcium carbonate, gypsum and other salts.

The erosional and depositional features of the desert soils vary considerably dependent upon the soil surface conditions, subsurface characteristics, slope and climate.

Susceptibility to wind and water erosion is high because the hot desert soils are loose, single grained and easily detached. Surface disturbance by machines and removal of the vegetative cover accelerates erosion.

Water

Most of the water resources of the desert biome are supplied by the larger rivers and streams of such water supply regions as the Columbia-North Pacific, Great Basin, Upper Colorado and Lower Colorado. The major rivers of these regions include the Snake, Columbia, Humboldt, Green, and Colorado,

and they receive most of their runoff from the higher elevations above the desert areas. The desert biome receives from less than 3 inches of precipitation annually in the hot desert of the Lower Colorado region to more than 16 inches per year in parts of the cold desert of the other regions. Many streams within the arid desert biome are ephemeral rather than perennial and provide little in the way of water resources. Almost all runoff from the desert areas is fully committed to agricultural, stock watering, and related uses. The quantity and quality of both surface and ground water varies from area to area within the hot and cold deserts.

Surface Water. Of the water resource regions mentioned previously, only one is a closed--the Great Basin. The surface waters of this basin drain into inland water bodies such as Great Salt Lake, Sevier Lake, Pyramid Lake and Humboldt Lake. The balance of the desert water basins eventually drain into the sea. Surface water resources within the desert areas include streams, rivers, reservoirs, lakes, springs, marshes and pot holes. These sources generally are fully committed for man's uses such as agricultural, power, municipal, domestic, industrial, recreational and fish and wildlife purposes.

Average annual runoff from the desert is very low and fluctuates greatly from one year to the next. It varies from less than 0.1 inch annually in the most arid section of the hot desert to more than 2 inches per year in small areas of higher precipitation zones of the northern cold desert.

The quality of water in most rivers, streams, lakes, and springs is generally adequate. However, in the Lower Colorado region some waters are high in dissolved solids and/or sediment concentrations. Average dissolved solids (ions of sodium, calcium, etc.) vary within the desert biome from less than 100 ppm (parts per million) in part of the Columbia-North Pacific region to more than 2,000 ppm in some areas of the Great Basin and Lower Colorado regions. Average sediment concentrations in streamflow vary from less than 280 ppm in part of the Columbia-North Pacific region to more than 30,000 ppm in northern Arizona and southwestern Utah. While averages for the latter area may range around 30,000 ppm, sediment concentrations as great as 700,000 ppm have been measured during peak flows on some streams.

Ground Water. As would be expected in such arid areas, ground water supplies vary within the hot and cold deserts. Good quantities of ground water exist in such desert areas as the Columbia Lava Plateau of the Columbia-North Pacific region and the alluvial basins of the Great Basin and Lower Colorado regions. The quality of ground water varies from area to area with a dissolved solid content ranging from less than 1,000 ppm to more than 35,000 ppm (dissolved solids include such ions as sodium, calcium, chloride, etc.).

Climate and Air

The climatic conditions within the desert biome are characterized by low, eratic precipitation, strong winds (especially in the spring), and hot summertime temperatures. The desert biome's subregions, the cold desert and the hot desert, are basically defined by their differing climates.

Cold Desert. This northern zone lies in a belt of westerly cyclonic storms. These storms bring most of the annual precipitation during the winter and early spring months except for Wyoming. The average annual precipitation ranges from 4 inches in the desert valleys to 16 inches on the higher plateaus. Temperatures range from 20° below zero to 115° above, with the mean daily temperatures varying from 20° in January to 75° in July. Mean wind direction and velocities tend to remain similar during winter and summer months. However, spring is the windiest time of the year with winds of 40 mph not uncommon. Strong winds carrying sand tend to sculpture this arid section. Especially in the valleys of the desert, atmospheric subsidence causes temperature inversions which result in blankets of fog covering inland basins for several days at a time. These conditions could be conducive to serious air pollution problems for relatively short periods.

Hot Desert. The southern zone is influenced by rather infrequent frontal systems during the winter that bring some moisture in from the west and north. During the summer, thunderstorms drop scattered moisture throughout the area. There are infrequent penetrations of moisture from the Gulf of California, the Pacific, and the Gulf of Mexico. The average annual precipitation ranges from 2 inches in the Lower Imperial Valley to 8 inches in the remainder of the area.

Temperatures range from 25° to 125° above zero, with the mean daily temperature varying from 55° in January to above 90° in July.

Spring months tend to be windy with sand-carrying winds of over 40 mph not uncommon. Other months experience similar direction but somewhat lighter wind velocity. Late summer thunderstorms occur with more frequence in the hot desert than the cold desert area with the exception of central Wyoming where 40 to 50 days of thunderstorm activity take place.

Within both zones there is a great diversity of local climates, ranging between the extremes of humid, cold, torrid, and dry. Wide local variations are caused primarily by topography but depend, too, on general air circulation, relative position in the desert biome, and latitude. There are wet periods and dry periods--in some years a marginal area will be favored with an unusually large share of moisture-laden winds; rain will fall, plants will thrive. In other years, the winds are dry and the desert community suffers.

Vegetation

The desert supports an extensive community of plants which essentially consist of three lifeforms. These are:

1. The annuals, which avoid drought by growing only when there is adequate moisture.

2. The succulents, such as the cacti, which store water.

3. The desert shrubs, which have numerous branches originating from a short basal trunk bearing small leaves that may be shed during the prolonged dry periods.

All have in common the characteristics necessary to survive the arid conditions which typify the desert biome. Together they are an important source of both food and shelter to the many forms of animal life that prevail.

All desert vegetation has a highly characteristic "spaced" distribution in which individual plants are thinly scattered with large bare areas in between. In addition to characteristic cacti and sage brushes, these plants include forbs, grasses, shrubs, and even trees. The Joshua tree with its misshapen form and unique leaves is perhaps one of the better known species found in the Hot Desert. The extensive "bare ground," however, is not necessarily free of plants. Mosses, algae, and lichens may be present to form a stabilizing crust in addition to functioning as nitrogen-fixing agents. Besides the perennial species of plant life, there also exist many species of annual forbs and grasses which make a show during brief wet periods. The desert environment offers particular advantages to these short-lived plants insofar as relieving them of the difficulties of water supply which beset the perennials.

From an ecological standpoint it is convenient to distinguish the two types of deserts on the basis of temperature, namely cold deserts and hot deserts. The former is characterized by sagebrush, greasewood, shadscale, and saltbrush while the creosote bush and yucca along with the cactus typify the hot desert. In the eastern sector of these deserts a considerable amount of grass is mixed with the shrubs; however, it has suffered greatly from overgrazing--the man-induced activity which has had the most significant impact on the make-up of the vegetation of the desert.

Unlike the grasslands and the forests in more humid climates, where vegetation renewal begins relatively quickly on disturbed areas, the desert is essentially lacking in plant succession. If a desert plant community is denuded, the plants that ultimately return are usually the offspring of the original species. Exceptions often take the form of such noxious species as halogeton which is poisonous to sheep and cattle. Nevertheless, there is no discrete series of weed, grass, shrub, or tree stages to succeed one another--preparing or ameliorating the soil or providing shade for the next stage to follow. Consequently, the restored community is the one that was there in the beginning, often taking decades to reestablish itself.

Animals

Wildlife - Terrestrial. Desert communities are of intense interest for the extremes of adaptation to the environment by both plants and animals. Some desert animals do not need to drink water (e.g., kangaroo rat, pocket mouse); others drink water at least occasionally, such as most birds of the desert which may exist on dew but which are most abundant near a free water source. Many, if not most, animals of the hot desert avoid temperature extremes by burrowing or occupying caves; many are nocturnal.

In the lower Colorado basin of Arizona and adjacent areas, there are more than 750 species and subspecies of birds and mammals. Not all of these are strictly desert species. Many may occupy only the fringes seasonally --such as the large ungulates which are almost absent from the desert. Carnivores are small and usually nocturnal. Species of kangaroo rat and pocket mouse are characteristic throughout the hot desert; both are nocturnal burrowers. Burrowers are very beneficial in moving soil from lower levels to the surface, mixing in organic matter, and in planting seeds.

Typical Colorado Desert animals include: black-tailed jack rabbit, desert coyote, kit fox, antelope ground squirrels, cave bat, big brown bat, leaf-nosed bat, lesser nighthawk, road runner, Cambel quail. In the Sonoran Desert of Arizona are ringtail, spotted skunk, wood rat, peccary, Gila woodpecker, numerous small birds during winter, bullsnake, three species of rattleshake, eight species of lizards. The Gila monster is typical of the cactus community. The river bottoms and flood plains, typical of more mesic areas, include some 32 kinds of birds. The Mojave Desert of sourthern California has fewer species of pocket mouse, no Gila monster, but otherwise many of the same animals with some differences in subspecies. The desert iguana and desert tortoise are commonly found here. The yucca moth pollinates the Joshua tree. Death Valley has 39 desert mammals and approximately 100 species of birds.

Northward, in the sagebrush and shadscale of the cold desert, many of the same animals are found. Major influents here, however, are Great Basin coyote, badger, antelope, locally the mule deer, great horned owl, prairie falcon, Swainson's hawk, golden and bald eagles, horned lark, and horned toad. There are fewer reptiles.

Wildlife - Aquatic. A wide range of water quality exists from the high barren desert mountain snow water to the very alkaline lakes such as the Salton Sea. All waters become important to aquatic animals in the arid conditions of the desert. Water shortage is emphasized by increasing human populations water need. Diversion of water for irrigation has contributed to deterioration of fish habitat in Pyramid and Walker Lakes, Nevada, once the home of Lahontan cutthroat trout and the depleted Cui-ui sucker.

Man has altered desert aquatic environment through the construction of large reservoirs such as Lakes Powell and Mead to small irrigation and stock watering reservoirs. Introduced exotic species such as black bass, crappie, carp, sunfish, the salt water species Corvina, Sargo and Bairdiella in the Salton Sea, and striped bass and coho salmon on some reservoirs and tailwaters all appear to do well while many endemic native species are reduced in numbers.

Threatened or Endangered Wildlife. One mammal, the Utah prairie dog, is endangered in the Great Basin. Its range is primarily in Piute County, Utah. The American peregrine falcon and prairie falcon are threatened species. In the Lower Colorado River region, the peregrine falcon is threatened, as is the Sonoran pronghorn. Mexican duck, masked bobwhite, Yuma clapper rail, and southern bald eagle are endangered. The spotted bat and Vegas valley leopard frog are threatened species.

There are more known threatened or endangered species of fish in the desert than in any other biome. This would be due, in part, to the many isolated watersheds and the precarious nature of many of the water bodies. Threatened (T) or endangered (E) fish include:

(T) Rio Grande cutthroat trout, New Mexico
(E) Gila cutthroat trout, Gila River, Arizona and New Mexico
(E) Piute cutthroat trout, California
(E) Desert pupfish, Arizona and California
(E) Tecopa pupfish, California
(T) Nevada pupfish, Nye County, Nevada
(E) Owens pupfish, California
(T) Devils Hole pupfish, Ash Meadows, Nevada
(E) Pahrump killifish, Nye County, Nevada
(E) Woundfin, Virgin and Parea Rivers, Utah
(T) Desert dace, Utah
(E) Moapa dace, Nevada
(T) Little Colorado spinedace, Arizona
(E) Pahranagat bonytail, Nevada, Arizona
(E) Humpback chub, Colorado, Utah
(E) Mohave chub, Lake Tuendae, California
(E) Colorado River squawfish, Utah, Colorado River

Other threatened or endangered fish species are the Gila topminnow, Gila River, Arizona and New Mexico; Cui-ui, Pyramid Lake, Nevada; and Pecos gambusia, New Mexico. Species whose status has not been determined include the Humboldt cutthroat trout, Colorado River cutthroat trout, Utah cutthroad trout, White River spinedace, Shoshone pupfish, and pallid sturgeon.

Domestic Livestock. The desert biome produces a variety of forage species that are highly acceptable to domestic livestock. Both cattle and sheep are grazed throughout, but relatively few sheep are grazed on the warm desert portion of the biome.

The forage shrubs that grow on the cold desert are especially well adapted for sheep winter grazing. The general pattern, then, is late fall, winter, and spring grazing by sheep and often by cattle as well. In the northern one-third of the biome, this is generally reduced to spring and fall use because of adverse weather conditions during winter. Cattle use in the cold portion is often of a spring-summer-fall pattern.

The warm desert portion of the biome is characteristically grazed by cattle year long. Some sheep use occurs but is limited to the winter season. While forage is especially well adapted to sheep use, sheep numbers have declined drastically over the years because of economic considerations. Conversely, cattle numbers have increased.

Bands of wild horses and wild burros now roam a number of ranges of the hot desert uplands and remote areas of the cold desert. These animals are protected by law. In some localized areas they have seriously depleted desert vegetation.

An interesting feature of the warm desert is the occasional production of an abundance of winter annuals because of favorable moisture conditions. This happens about one out of five years on the average and permits a tremendous increase in livestock use for a brief period.

Soil Organisms. Soil organisms play the same basic role in soil development in the desert biome as they do in other biomes (e.g., the previously discussed grassland biome). However, the supply of organic matter is much more limited in desert soils and its breakdown by micro-organisms such as nematodes and protozoa is much slower. This is due to the unfavorable conditions for the growth and activity of such organisms. While the soil is often warm enough, sufficient moisture is very seasonal and discontinuous. Some desert soils are largely devoid of plant life and micro-organisms that would help develop conditions to support such life due to harmful excesses of salts such as are found in the dry lakebeds of the hot desert.

Human Settlement and Use

Population settlement patterns in the biome tend to be light in density for a majority of the area. Most counties in 1970 had a density of less than 10 persons per square mile compared to a national average of 57.5. Exceptions to this are the regional market centers and those areas which have developed extensive agriculture through irrigation. Population concentrations occur in the vicinity of El Paso, Texas; Phoenix-Tucson, Arizona; Southern California-Las Vegas, Nevada, Reno, Nevada; and in a linear corridor from Boise, Idaho, to Salt Lake City, Utah.

In spite of low population densities, most of the biome experienced a net population gain during the 1960-1970 period. Very sparsely populated areas of Nevada and Arizona, for instance, experienced a gain of 13.3 percent or over (national average is 13.3 percent gain 1960-1970).

The entire area is dependent upon a limited water resource. Principal industries in rural portions of the biome are agriculture and mining. Urban centers tend to be new, modern, with growing manufacturing and service oriented industries. The Reno-Las Vegas areas have expanded entertainment and tourish services into a major industry.

One of the reasons for significant population and economic growth in the biome during recent years has been its "amenity" resource. Warm and typically cloudless weather, low population, and ready access to recreation--open space lands add up to a high quality natural environment. Tourism and recreation are growing rapidly. Subdivision and sale of lands for retirement or recreational use is particularly attractive in many rural areas. In urban areas, the "quality environment," in combination with ready access to services, educational institutions, and a labor market, form a magnet for industries for which ties to raw material sources or national market centers are not a major constraint. Typical of these are apparel, electronics, or aircraft manufacturing.

Land Uses

Agriculture. Native vegetation covers a major portion of the area and is used for livestock grazing which is the principal agricultural activity of the biome (on an area basis). Livestock operations include both cattle and sheep grazing. The former are primarily cow-calf operations while the latter are oriented toward lamb production. The bulk of these lands are in some form of public ownership. Extensive areas are used for military operations or other government purposes, such as Atomic Energy Commission test grounds. Livestock grazing is permitted in such areas on a limited basis.

Natural vegetative productivity for grazing decreases, generally, from north to south in the biome. Areas in the hot desert become marginal and, in extreme cases, unsuitable for livestock use.

Limited areas physically suited for irrigation have been the key factor in determining the extent of irrigated portions. Vast areas of productive soils, but lacking water, exist in a native condition. Important irrigated crops in the cold desert are potatoes, sugar beets, grains and hay.

Warmer climate in the hot desert allows the growing of subtropical fruits, cotton, and specialty crops.

Wilderness. Areas formally designated and managed as wilderness or primitive are limited in the biome. However, potential areas exist. Presumably they will be considered for use in one of the above categories as land use planning progresses. Such areas exhibit native vegetative cover, are large in size (over 5,000 acres), and lack any significant development such as roads, buildings, or other facilities.

Mining. Minerals and mining were a key factor in the original development of much of the biome. Gold and silver booms were in many cases the thrust for initial settlement. Current mining or potentials of significance are coal, oil, oil shale, phosphates, copper, gold, silver, mercury, lead, zinc, iron, tungsten, gypsum, sand, gravel, and stone in the eastern portion of the cold desert and copper, gold, molybdenum, lead, zinc, silver, tungsten, lime, sand, gravel, and stone in the hot desert (Phoenix-Tucson area). Potential geothermal steam sources are being explored in such areas as the Imperial Valley on the Mojave Desert.

Current production of oil and gas is limited in the desert biome, occurring along the eastern portions of the desert in Wyoming, Utah, Colorado, and New Mexico.

Recreation. Extensive recreation uses occur throughout the biome. Pressures for use increase nearer large population concentrations. The western portion of the hot desert, which is adjacent to the Los-Angeles-Las Vegas-Phoenix urban areas, is receiving extremely high use by the general public. Open space such as this represents a valuable recreation resource.

Surface water is very limited. Where it does occur it is used heavily for the more intensive forms of water based recreation activities.

Urban. Urban land uses in the biome are separated by vast areas of open space. Settlements outside metropolitan areas tend to be small with populations of less than 10,000 persons. Settlements which serve a local market area or those which are developing a tourism-recreation industry will probably experience an increased demand for residential, commercial, and industrial land uses. It appears that large-scale demand for recreational or retirement homesites will continue to expand in remote areas.

Metropolitan areas have experienced phenominal growth recently. The Las Vegas urban area, in 1970, had a population of 229,500 with a growth rate of 165 percent over the decade. The urbanized area increased from 35 square miles to 121 during this period. Other metro areas such as Phoenix and Salt Lake City experienced similar growth. There appears to be no reason why the extraordinary growth of metro areas should not continue in the future. Large areas of adjacent rural land will be required for urban expansion.

Aesthetic Values

The term "desert" for many people carries with it a connotation of sand dunes and desolation somewhat inhospitable for man. People now are discovering the desert for its wide variety of interests.

Although there are many similar characteristics throughout, the desert biome can be more clearly described under its two sections--the Cold Desert and the Hot Desert.

Cold Desert. The land form of the cold desert is typically the flat dry bed of an ancient lake or the relatively low rolling hills of the great basin, occasionally interrupted by a small mountain range. Seldom is the observer out of sight of a mountain somewhere in the arc of view. The texture of the cold desert is generally the relatively soft texture of the vast expanses of sagebrush broken occasionally by a bare ridgeline, a steep gully, or a flat dry lakebed. Color is not an important factor in the cold desert. It is generally dominated by the gray-green of the sagebrush or the flat grays and browns of the soil typical to the region. Soil color becomes a more important factor in some portions of the cold desert in Wyoming and Colorado where the red sandstones make up the parent material.

Lines play a very minor role in the makeup of the character of the cold desert. The lines that are evident are primarily those caused by man--the roads, fences, and powerlines that occasionally cross through the area. Although these intrusions are few, the ones that are present are obvious for many miles.

As in the grasslands, scale is difficult to define. The vastness of the open space with few vertical elements in the landscape makes it hard to tell just how far an observer is from a given object.

Hot Desert. The character of the hot deserts of the southwest is considerably different than that of the cold deserts. The form is more often the remnants of eroded mesas with broad flat valley bottoms. Where there are live streams running through the desert, erosion is very active and steep, sometimes vertical, canyons are incised into once flat mesas. The prime examples of this are the canyons of the Colorado and Snake Rivers.

There are distinct horizontal and vertical lines evident in the mesa tops and sharp dropoffs to the valley floors. Color becomes a dominant factor in the hot desert. The rich reds and browns of the exposed soil and rocks are much more in evidence than in the sage covered cold deserts.

The texture is fairly coarse because of the widely scattered vegetation. The rocks and soil are exposed over much more area.

Scale is much easier to define in the hot deserts. The vertical lines created by the edges of eroding mesas along with the larger and more scattered vegetation provide the observer with the elements needed to more accurately judge size and distance.

Geologic Values of Human Interest

The deserts have some of the dullest sightseeing geology and some of the most intriguing. In the basin and range areas of Nevada it tends to be somewhat repetitive in gray with long sweeping views of the basins and short quick trips through the mountain ranges. Certain areas, particularly the Colorado Plateau, are highly eroded, mostly in colorful formations which produce delicate erosional features, easily recognizable

"picture book" geologic structures, and grand views of the total. Scattered throughout the biome are some of the most tremendous canyons in the world--the Grand, the canyons of the Snake, the Owyhee, the Green, and others. Also present are sand dunes, volcanic features, playas, and fault structures.

Archeological Values

Remnants of both the Big-Game Hunting Tradition and Old Cordilleran Tradition cultures are found in the desert biome--the former to the east and south and the latter to the north and west. Hunters in southeast Arizona hunted mammoths and other big game. Peoples in the Nevada desert were mostly gatherers but did hunt small game, including waterfowl around the many Pleistocene lakes in the region.

These two traditions developed into the Desert Culture Tradition, a basic gathering culture that existed on the many grasses, pinyons, insects, acorns, small game, and other products of the hot and cold deserts.

As the result of strong influences from the valleys of Mexico, several Agricultural cultures developed from the desert Archaic base in the hot desert and the southern portions of the cold desert. Irrigation farming was practiced, large communal structures were constructed, and highly organized and structured social systems were developed. During the same period, people with the desert Archaic Tradition still co-existed and others such as the Apachean groups moved into the desert. This was the situation at the time of first non-Indian contact by the Spaniard explorers in the early 1500's.

The large archeological sites of the desert biome are easy to detect; but the attention paid to these sites tends to allow other, less pretentious sites--such as agricultural terraces, campsites, chipping areas, small canals, and shallow caves--to be neglected and destroyed. Water development projects can lead to the destruction of many sites because there is almost a one-to-one relationship between archeological sites and water sources in the desert. The water sources were as important to prehistoric man as for modern man.

Large rock alignment figures called "intaglios" occur along the Lower Colorado River. They are difficult to see from the ground, and driving over them tends to obliterate them.

3. Woodland-Bushland Biome

The woodland-bushland biome is widespread in the western United States, but discontinuous, occurring as biological islands at the higher elevations within the grassland and desert biomes. It forms a transitional zone between these biomes and the coniferous forest biome. Its general range

is shown in figure II-23. In many ways its vegetative characteristics are similar to the cold desert.

Though the proportion of federally managed land and subsurface resources is generally high throughout this biome, oil and gas exploration and production is limited, with the exception of a portion of eastern Utah.

Ecological Interrelationships

The woodland-bushland community ecosystem is diverse and occurs scattered over a wide area. The California chaparral-bushland is fairly well defined but the other woodland communities occur principally as an ecotone between the desert biome and the forest biome. Thus the ecological interrelationships are closely related to, and dependent upon, these two major biomes.

Most of the vegetation is woody trees or shrubs resulting in storage of nutrients and slow cyclic action. Nitrogen is believed to be a limiting factor in productivity. At higher elevations the interrelationships resemble the forests with rapid energy turnover and a greater lag of autotrophic production.

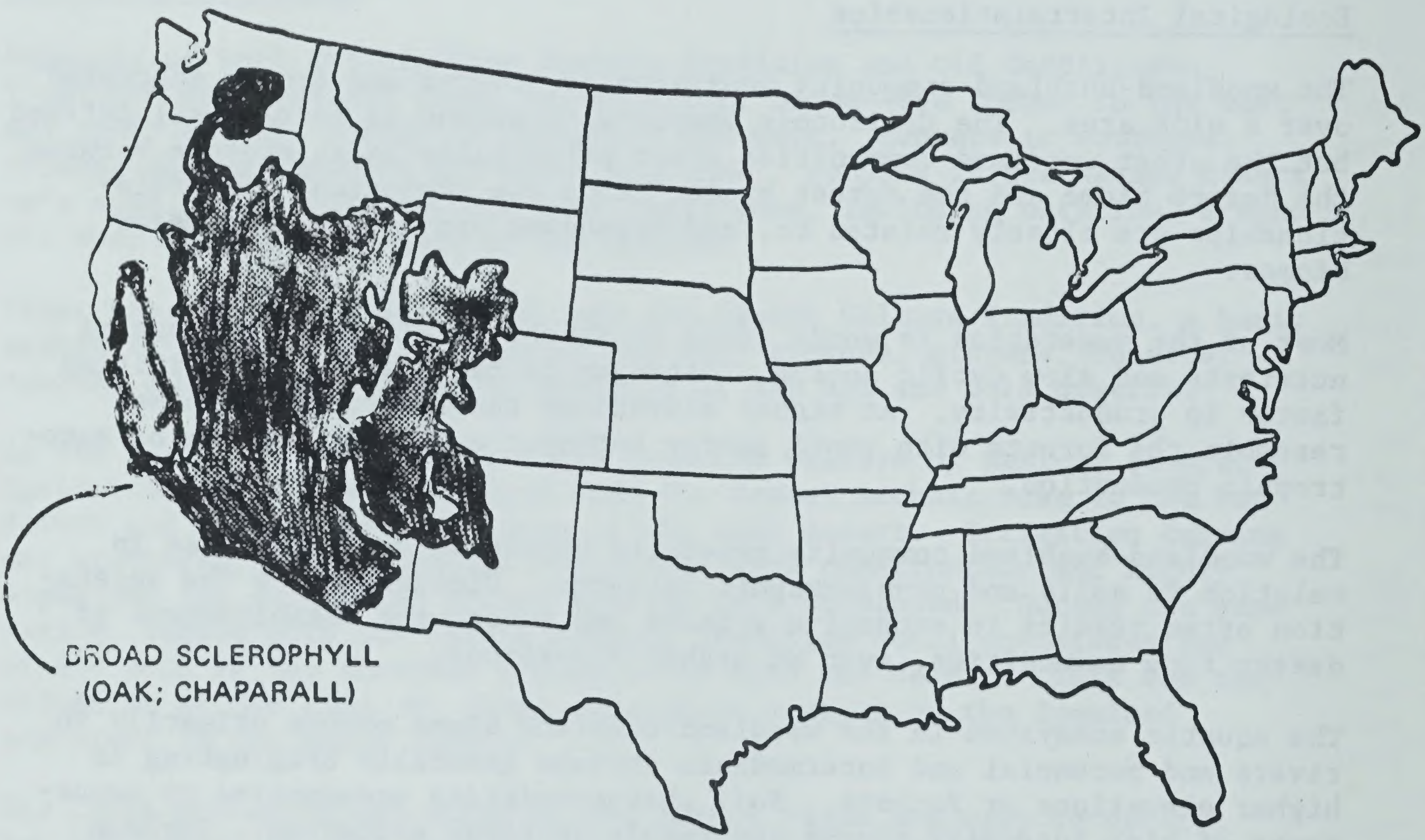
The woodland-bushland community generally occurs on unstable areas in relation to soils and physiographic features. Disturbance to the vegetation often results in extensive erosion and subsequent establishment of desert type communities, even at higher elevations.

The aquatic ecosystem in the woodland-bushland biome occurs primarily in rivers and perennial and intermediate streams generally originating in higher elevations or forests. Soil characteristics accompanied by occurrence of high intensity storms can result in heavy siltation. Surface disturbance accelerates siltation. However, the surface waters do support warm water, cold water, and anadromous fisheries where suitable habitat occurs. Information regarding the aquatic ecosystem and the microbial ecology of the brushland is scarce and should be more adequately defined.

The woodland community ecosystems, because of past history of overuse and relationship to other associated communities, are still in a transition stage. There is sufficient evidence to indicate that woodland communities, especially pinon-juniper, have extended themselves into former grasslands and sagebrush sites. This trend is still in evidence and it is expected to continue until natural forces or surface management practices come into balance with climatic, site, and environmental factors

There is a close relationship between the woodland ecosystem and fire. Under the natural system, fire probably was a major factor in maintaining a balance between the woodland and adjacent plant communities. Fire protection has significantly contributed to the expansion of Schlerophyll and pinon-juniper woodlands.

Figure II-23. Woodland-Bushland Biome



Note: The Woodland-Bushland Biome occurs as islands within portions of the Grasslands and Desert Biomes.

The California chaparral has been described as an example of a catastrophic climax vegetation. The vegetation in this area, combined with hot dry summers, presents a recurring and extreme fire hazard. Fire removes the shrubby vegetation. Herbaceous vegetation then develops rapidly and occupies the site until the shrub dominance is reestablished. Removal of heavily dominant shrub ecosystem by fire or other disturbance can result in disastrous floods and extensive siltation.

Geology, Land Forms, Topography and Soils

Most of the woodland-bushlands are located on the high hills and mountains of the deserts where the soils have a slightly higher organic content and the annual precipitation is higher than in the intermediate desert valleys. These higher hills and mountains are capped with the Quaternary and Tertiary volcanics or the Upper and Lower Paleozoic sediments. The soils are less susceptible to erosion and are more stable than the soils of the desert. The controlling factors are the physiographic differences which in turn are a result of the tectonics or the faults within the region. For a detailed description of the geology, soils, and topography, refer to the description of the desert biome.

The woodland areas in central and southwestern California lie within the physiographic province of the Pacific mountain system. The woodlands occupy the dipslope of the foothills zone between the San Joaquin Valley and the mountains which surround the valley. They continue on the dipslope zone of the mountains and hills along the west coast of California on into Mexico.

Mesozoic sediments of Triassic, Jurassic, and Cretaceous age outcrop in the area along the western foothills of the San Joaquin Valley, while Tertiary sediments are present along the northern foothills. The dipslope to the northeast are Upper Paleozoic and Lower Mesozoic sediments while the southeast foothills are chiefly granitic rocks of Lower Tertiary and Mesozoic age. The formations of the foothills along the southwest California mountains vary in age from Mesozoic to Tertiary and include both the sedimentary and granitic intrusive rocks.

Many extensive known faults occur within, adjacent to, and pass through this biome. The pronounced San Andreas fault zone is the major strike slip fault along the California coast; several portions or branches of this fault have created surface features of the western foothills of this biome. This is also an active earthquake zone with many epicenters of slight to major magnitude being recorded from the 1600's to the present.

The soils of the woodland surrounding the San Joaquin Valley are predominantly of the Aridisol order with warm, dry surfaces, while the soils of the foothills along the west coast are of either the Entisol or Mollisol order but also have warm-dry surfaces.

Minerals

In the major portion of the woodland-bushland biome, minerals generally are the same as those occurring at immediately lower elevations on the desert. Outside the desert area, most of the woodland-bushland biome is in California. Here the leasable minerals are generally of the evaporite bedded types, with most of them being near the biome boundary bordering the California prairie grasslands. They are primarily in the sediments. The minor coal is low-volatile bituminous and also some lignite. The leasables on the western side of San Joaquin Valley in the marine sediments are in areas which could be considered valuable for oil and gas. The locatable minerals are found both as vein and bedded deposits and for the most part in the sediments on the eastern flank of the San Joaquin Valley. The deposits very likely are closely associated with the Sierra batholith and also the faulting throughout this biome.

The predominant locatable minerals are gold, silver, iron, copper, tin, vanadium, chromium, manganese, barite, gypsum, magnesite, brucite. The predominant leasable minerals are sodium, iodine, borates, sulfur, phosphate, and minor coal, oil and gas.

Water

There is a wide range of water resources within the woodland-bushland biome. As found in the grassland and desert biomes, most of the water is supplied by rivers and streams with headwaters in the higher elevation forests above the woodland-bushland areas. These higher elevations provide most of the surface waters.

The woodland-bushland areas generally receive from 12 to 25 inches of annual precipitation with extremes of up to 50 inches in the California oak-chaparral area. Both ephemeral and perennial streams are found in the woodland-bushland areas. Flood waters of ephemeral streams, which are typical of the juniper areas, are generally heavy laden with silt. High intensity summer thunderstorms are typical of the juniper areas and flood runoffs are not uncommon. Both quantity and quality of surface and ground water varies from area to area within the woodland-bushland communities.

Surface Water. Like those found in the grasslands and deserts, surface water resources of the woodland-bushland areas include streams, rivers, reservoirs, lakes, and springs. Uses include domestic, municipal, industrial, power, agricultural, recreation, and fish and wildlife.

While the lower precipitation zones (10" to 15") yield very little annual runoff (0.1" to 0.5"), the higher precipitation zones of 15 inches to 25 inches yield important annual runoff of from 0.5 inch to more than 10 inches. For the California oak-chaparral area, annual water yield may be as high as 20 inches from a precipitation of up to 50 inches which comes mostly as rainfall during the winter months.

The quality of most surface waters within the woodland-bushland areas is generally adequate with the exception of some of the juniper area streams which are high in silt content. Average dissolved solids (ions of sodium, calcium, chloride, etc.) range from less than 100 ppm (parts per million) to more than 2,000 ppm. Average sediment concentration of streamflow varies from less than 280 ppm in the oak woodlands to more than 30,000 ppm in some of the juniper associated areas.

Ground Water. The ground water supplies of the woodland-bushland areas vary from area to area as in the grasslands and deserts. Good quantities of ground water are found in some areas such as those of the alluvial basins of California, Nevada, and Arizona. Ground water of the woodland-bushland areas is used for such purposes as irrigation, domestic, municipal, and stock watering supplies.

Ground water quality varies from area to area but is generally good with a dissolved solid (ions of sodium, calcium, chlorides, etc.) content that is normally less than 1,000 ppm.

Climate and Air

Climatic conditions vary greatly within the woodland-bushland biome. Basically, the deserts east of the Sierra Nevada Range are comparatively dry because of the mountains' "rain-shadow" effect while the California foothills come under the influence of moisture laden marine air.

Desert Foothills. In the northern section of the desert foothills about 75 percent of the annual precipitation falls during the winter months. In the southern area of the desert foothills, the precipitation is somewhat even throughout the year with the months of July and August being the dominant rainy months. The average annual precipitation ranges from 10 to 20 inches.

Temperatures range from 20° below zero to 100° above, with the mean daily temperatures varying from 20° in January to 85° in July.

Windiness--especially in the spring--is characteristic of the desert foothills. Dust devils are frequently seen on hot days along with summer thunderstorms. Local winds of 40 mph are not uncommon. The topography generally precludes fog conditions from taking place except in isolated areas (small basins).

California Foothills. Winter storms bring most of the annual precipitation with the months of June, July, August, and September remaining dry. Average annual precipitation ranges from 20 to 40 inches in the north and 10 to 20 inches in the southern part of the area.

Temperatures range from 5° to 112° with the mean daily temperatures varying from 45° in January to 70° in July.

Winds are generally light and from the south during winter months except during the passage of storms when winds frequently exceed 30 mph. During the summer, winds are out of the northwest at about 5 mph.

Fog occurs only during winter months and then only in small foothill valleys where air becomes trapped by topography. Thunderstorms occur only about five days out of every year, generally in the late spring or early fall.

Vegetation

The woodland-bushland biome is discussed by three general categories:

1. Broad Sclerophyll

2. Oak Woodland and Bushland

3. Pinon-Juniper

Broad Sclerophyll (Oak-Chaparral). In the mild temperate region from central Oregon through California, the vegetation generally consists of trees or shrubs with hard, thick evergreen leaves. Three life forms--sclerophyll forest, woodland, and chaparral--merge with one another without distinct regions and little or no successional relationship. All are best developed on the coastal ranges of southern California but their ranges extend from southern Oregon southward through the coastal mountains as well as through the Sierra Nevada foothills into lower California.

Chaparral is found in alternating patches in most parts and occupies the greatest area. In California, some 5 to 6 million acres of slopes and canyons are covered with chaparral.

The sclerophyll forest generally occurs in the more highly developed north slope sites. Scattered trees or woodland types occur with an understory of grass, chaparral, or sagebrush. The woodland-grass type surrounds the California grassland, extends northeast along the Coast range, and occurs in other scattered areas.

The greatest value of the broad sclerophyll is watershed protection. The chaparral, for example, consists of shrubs which form dense canopy thickets with little or no understory vegetation. It occurs on deep, loosely consolidated slopes which are highly erosive. Removal of the vegetation by fire or other means can result in disastrous floods into thickly populated downstream areas. The long dry summers result in high fire danger, and fire is an important factor in the ecological development of the sclerophyll.

Oak Woodland-Bushland. The oak woodland and oak bushland vegetative types occur generally scattered as ecotones between the desert biome and the pinon-juniper community. Geographical location of the communities is dependent upon topography and climate. The oak bushland community is found in the Rocky Mountain foothills and the interior ranges in Utah and

Arizona at elevations between 5,000 and 8,000 feet. The vegetation usually does not form a continuous cover but occurs in dense clumps, some of which may be quite large. In addition to oak, the vegetation generally consists of deciduous shrubs of numerous species, the composition of which is dependent upon elevation, topography, and aspect. The number of plant dominants is large with several species appearing regularly in each community.

The oak woodland community occurs generally in southern Arizona and New Mexico. In addition to oak, juniper, small trees, undershrubs, and grasses are interspersed. This community is also somewhat scattered and understory vegetation varies from cacti and yucca to grasses and shrubs. Topography is usually steep to rolling and soils are generally erosive.

Pinon-Juniper Woodland. The pinon-juniper communities cover an area of approximately 60 million acres interspersed generally through the cold desert biome in the western United States. A majority of the type occurs in the five states of Nevada, Utah, Colorado, Arizona, and New Mexico.

Pinon-juniper generally occurs at elevations between 5,000 and 7,000 feet Stand density varies from a very few trees per acre to 600 or more per acre. A rather open stand is typical, but areas of dense trees are not uncommon. Very often the stand thickens progressively from scattered trees at lower elevations. Maximum density occurs just before the rapid transition is made into timber or mountain shrub types. The lower, sparse part frequently consists of juniper reproduction on sagebrush or desert grass sites. Pinon pine generally becomes established following juniper establishment. Since junipers are more drought resistant, they are commonly found at elevations 500 feet lower than pinon. Broad areas with savannah characteristics occur primarily in New Mexico and Arizona where the understory is composed of mixed desert grasses and shrubs.

The herbaceous undercover varies inversely with the tree and shrub density. However, it has been observed in Arizona that shrubs may tend to increase with the number of trees until a tree density of 50 percent is reached. The shrub undercover then decreased sharply where tree canopy exceeds 60 percent ground cover.

Plant production under natural conditions is greatest in the southern portion (Arizona and New Mexico) of the pinon-juniper type. This is true of both trees and understory. Trees will grow to 40 feet on the better sites in the south while 30 feet is about maximum in the northern areas.

The flora of different physiographic areas of the pinon-juniper type are conditioned by climatic and other factors encountered. Prominent plant species and associations vary accordingly.

Animals

Wildlife - Terrestrial. In this biome, wildlife can best be grouped as habitants of the pinon-juniper, the interior oak woodland, and the coastal (California) chaparral. Few animals are restricted to the pinon-juniper zone although many are typical of it. The pinon jay and the gray titmouse birds are characteristic permanent residents largely restricted to this biome. The whiteheaded woodpecker winters in the pinon-juniper.

In the Kaibab-Zion area, the mule deer is dominant in winter. The mountain lion is the chief predator along with the coyote and bobcat. The desert wood rat and the rock ground squirrel are characteristic residents. The nocturnal pinon mouse is perhaps the most abundant mammal found throughout the woodland. The cliff chipmunk, black-tailed jack rabbit, and Nuttall's cottontail are common residents. Nesting birds include the golden eagle, red-tailed hawk, and scrub jay.

There is a comparatively small number of reptiles in the pinon-juniper; they are most common at lowest elevations. Reptiles include the sagebrush swift, several lizards, and snakes including the rattlesnake and kingsnake.

In New Mexico, the Mexican wood rat reaches its greatest abundance. In the Big Bend area of Texas, typical animals include the white-tailed deer, gray fox, brush mouse, several lizards, and the rock rattlesnake.

More mammals occur in the oak-juniper of southern Arizona and New Mexico than in the pinon-juniper zone. These include the ringtail, white-tailed deer, fox squirrel, turkey, bobwhite, and mourning dove. Forty-two permanent resident birds, at least 16 species of lizards, and as many snakes have been listed.

In the Rocky Mountain bushland, most vertebrate animals are either transitory or seasonal. The mule deer is an important dominant along with the usual large predators. The long-tailed weasel, spotted and Great Basin skunks are common. Most rodents remain active. Hibernating mammals include the jumping mouse, marmot, Uinta and golden mantled ground squirrels. There are many birds, including winter visitors. Large mixed flocks of birds winter in canyon bottoms or other sheltered locations. Of 11 reptiles, only the rubber boa appears to belong primarily to the bushland.

In the scherophyll bushland or chaparral in California and southern Oregon, mule deer of several subspecies are wide ranging; turkey, wild boar, and several exotic game species can be found. Typical mammals include the mountain lion, bobcat, coyote, gray fox, wood rat, skunk, and brush rabbit. Merriam chipmunk, California mouse, and five-toed kangaroo rats are confined to chaparral. There are numerous small birds and lizards; but except for the tree frog, amphibians are absent.

Wildlife-Aquatic. Aquatic wildlifé forms are characterized by representatives of both cold and warm water fish species. A variety of aquatic environment exists in small, sometimes intermittent streams, upper reaches of larger rivers, impoundments, and some natural lakes.

Waters are moderately rich in nutrients and microorganisms and water quality may be fair to good. Some streams may carry heavy silt at times in brushland areas with the better quality and more stable waters in wooded areas.

There is considerable fish species diversity, including many exotic species introduced into the area. Representative fish are trout, salmon, whitefish, striped bass, sturgeon, shad, catfish, suckers, carp, squawfish, shiners, minnows, dace, chubs, sculpins, sunfish, perches, basses, and other sunfishes.

Threatened or Endangered Wildlife. There are no known threatened species of mammal, bird, or fish unique to this biome. Some threatened or endangered species range into it, including the spotted bat, Utah prairie dog, San Joaquin kit fox, blunt-nosed leopard lizard, Colorado River squawfish, the humpback chub, and White River (mountain) sucker.

Domestic Livestock. The location of the woodland biome at the upper elevational margin of the desert biome, and interspersed throughout it as biological islands, results in livestock distribution and use similar to that of the desert biome. In general, the pinon-juniper portion serves as spring and fall range for both sheep and cattle and as summer range for cattle in some areas. Some winter sheep use occurs in the southern half as well as some year-long cattle use. Horse use is minor, although portions of some of the established wildhorse ranges are located in this biome.

The forage species in the California portion (chaparral and oak woodland) are largely winter annuals. Therefore, grazing use occurs for the most part during the winter and early spring when forage is at its best. Cattle have been on the increase and sheep have declined over the years. Horses have reached a point of relative stability after delining drastically.

In general, ranches are cow-calf operations or produce lambs. In the California woodlands, the practice of running steers or yearlings is not uncommon because of the seasonal nature of the forage.

Human Settlement and Use

Human settlement and use in this biome, with the exception of the California portion (oak-chaparral), is very similar to that described in the desert biome.

The California oak-chapparal is adjacent to, and partially includes, large metropolitan areas. Population densities, therefore, vary from over 250 persons per square mile in expanding suburbs to less than 10 in undeveloped areas. Even the more isolated areas, which are still rural in nature, reflect the economic and social influence of nearby metropolitan areas.

The vegetation in this area, combined with periodic hot, windy and dry climatic conditions, presents a recurring and extreme fire hazard to all population and land uses.

Land Uses

Agricultural. Rough and steep topography limit agriculture in most areas to livestock grazing. Production of livestock on range is the principal land use in the biome because of this factor. Very minor portions, mainly in narrow valleys, are irrigated and intensively farmed. Ranches tend to be isolated.

Recreational. The biome supports many extensive recreational uses. Big game and upland game birds provide hunting opportunity in most areas. Areas near population concentrations receive heavy recreational use which is expected to increase in the future.

Mining. As in the desert biome, many areas have had a past history of metallic mining (such as gold in the California Mother-Lode Country) which has since decreased in significance. Areas within Colorado, Utah, and New Mexico have produced oil and gas and potentials may be relatively high. The western side of the San Joaquin Valley of California also has some valuable oil and gas bearing formations with a number of currently producing wells.

Wilderness. Extensive roadless or undeveloped areas exist with primitive qualities. Streams within these areas may meet criteria for wild rivers; a number are now under study. The California oak-chaparral tends to be more developed and therefore has less area with primitive or semi-primitive qualities.

Forest Products. Woodland components of the biome support a small, but locally important, source for cord wood and fence posts. Pinon pine nuts are traditionally harvested by some Indian cultures in the pinon-juniper zones.

Urban. Small, isolated ranching or mining towns are scattered throughout the area, as is typical in the desert biome. Suburban expansion is occurring in California and to some extent in the Salt Lake City area. In California, fire hazard and suburban development present a major problem.

Aesthetics

The woodland-bushland visual environment is one that varies greatly. It ranges from a semi-desert to a wooded foothills landscape.

Since the valley bottoms in the West are also the principal travel routes, much of the woodland-bushland type is exposed to the view of the traveling public. In some areas this view is from a considerable distance. In others it is directly adjacent to the travel route.

The land form of the woodland-bushland communities varies from relatively flat valley bottoms through the low rolling foothills to deep cut canyons and high mesas. Most typical of these would be in the rolling foothill area.

The texture varies as the density of the stands vary, from a continuous dense canopy to an open, scattered random pattern.

The color varies almost as much as the land form and the texture. Where there is a fairly continuous canopy, the gray-green of the vegetation is predominant. As the stands thin, the color of the soil or rocks becomes dominant.

Lines are only evident where there is an abrupt change in the vegetation type or where there has been some disruption of the vegetation, i.e., roads, powerlines, etc. Scale is more easily defined and much more obvious in the woodlands than in the grasslands or desert.

Geological Human Interest Values

Most geological features of interest are similar to those found in the surrounding desert or grassland areas at elevations which have been previously discussed. For example, the woodland-bushlands may cover the tops of high mesas which are an integral part of the dramatically eroded areas on their flanks. In the California foothill woodland areas, there are numerouss faults. Large ones, such as the San Adreas fault, passing through both prairie and woodlands exhibit visible displacement

The Broad Sclerophylls in California cover the "Mother Lode" country of the 1849 gold rush. The area is rich in lore, replete with old ghost towns and remains of the mining activities such as dredging piles and huge hydraulic cut banks.

Archeological Values

Prehistoric peoples who used the juniper associates and the oak woodlands were, for the most part, the same people who inhabited the hot and cold deserts. Similarly, the prehistoric people in the borad sclerophyll community of southern Oregon and California were similar to those in the California and Palouse prairies. Old Cordilleran Tradition developed into an Archaic Tradition; and the latter continued to contact times.

4. Coniferous Forest Biome

The coniferous forest biome ranges widely through the western states where precipitation is adequate to support forest growth. The biome consists of three fairly well defined component forest types as mapped in figure II-24.

Taiga Coniferous Forest. This type spreads across interior Alaska with narrow fingers following water courses to the timberline of the Brooks Range.

Montane Coniferous Forest (and Alpine Communities). These forests cover the Cascade and Sierra Mountains in Washington, Oregon, and northern California from woodland transition to timberline and then extend eastward to the woodland types of the Great Basin and the Rocky Mountains above the transition to the grasslands of the Great Plains.

Northwest Coastal Forest. The heaviest of the coniferous forest types, a rain forest, it extends along the Pacific coast from southern Alaska to western Washington, western Oregon, and northwestern California.

The extent of federally managed lands and subsurface resources in the coniferous forest biome is relatively high, especially in the Montane and Taiga regions. Oil and gas exploration and production activities are low, with the exception of some portions of the central Rocky Mountain area.

Ecological Interrelationships

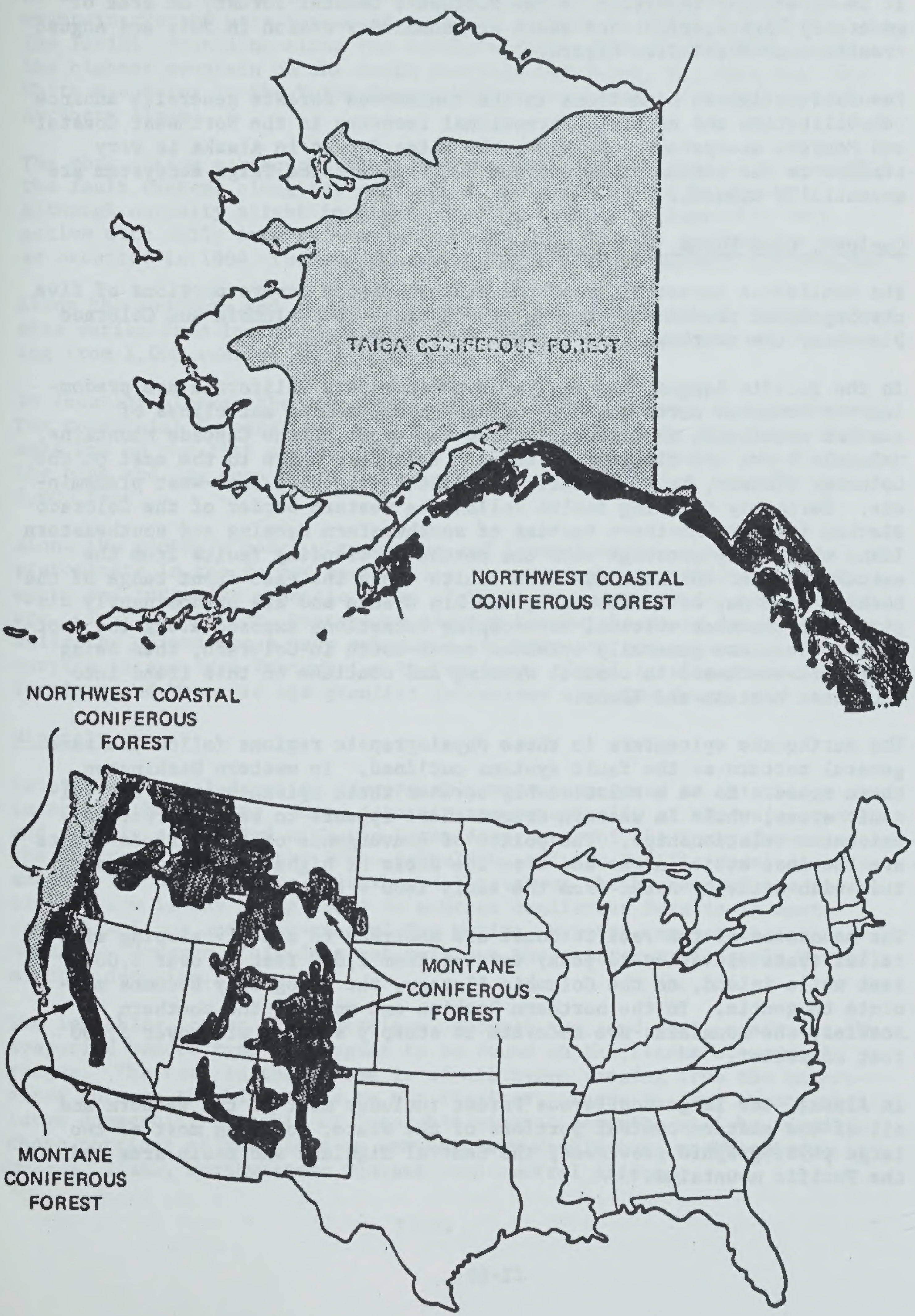
The three broad western coniferous forest communities are characterized by tree species generally providing dense canopy cover and heavy shade yet woodland-bushland and grassland communities occur interspersed throughout, especially in the Montane Coniferous Forest communities.

The precipitation input to the coniferous forest ecosystem is high and there is generally optimum moisture for maximum production of the living components of the biome. The forest watershed is a primary source of water flowing through other biomes at lower levels and provides much of the water needs for the western states.

The heavy shade, with leaf retention throughout the year, results in less organic matter and poor understory vegetative development. Soil organisms occur in moderate amounts and a large volume of nutrients is contained in the biomass of large trees. The turnover time in ratio of biomass to production is slow, and overexploitation could reduce productivity by physical removal of the nutrients from the ecosystem.

Coniferous forest ecosystems generally occur on moderate to steep slopes with soils which are often unstable and erosive. Physical surface disturbance can adversely affect the inland aquatic ecosystems as well as streams and rivers. The aquatic ecosystems are complex and diverse. The anadromous fisheries are unique and directly dependent upon the forest watershed, especially in the Northwest Coastal Forest.

Figure II-24. Coniferous Forest Biome



As in the woodland-bushland biome, fire is an important ecological factor. It is especially important in the Northwest Coastal Forest, an area of generally high rainfall but where an annual dry season in July and August creates a critical fire hazard.

Favorable climatic conditions in the coniferous forests generally enhance rehabilitation and natural successional recovery in the Northwest Coastal and Montane ecosystems. However, the Taiga forest in Alaska is very similar to the tundra biome and the functions of the Taiga ecosystem are essentially unknown.

Geology, Land Forms, and Topography

The coniferous forest biome of the western states covers portions of five physiographic provinces: the Pacific Ranges; the Columbia and Colorado Plateaus; the northern and southern Rocky Mountains.

In the Pacific Ranges, the faults in northwestern California are predominantly oriented north-south as are the sharp folded anticlines of western Washington and Oregon. Along the crest of the Cascade Mountains, volcanic cones are distinctive surface features, while to the east on the Columbia Plateau, broad anticlines oriented generally east-west predominate. Northerly trending faults follow the western border of the Colorado Plateau into the northern Rockies of southwestern Wyoming and southeastern Idaho where they converge with the northwest trending faults from the eastern side of the Rockies. The faults along the east front range of the Rockies come out of Mexico along the Rio Grande and are predominantly displayed in the near vertical outcropping formations exposed along the foothills. They are generally oriented north-south in Colorado, then swing northwest-southeast in central Wyoming and continue on this trend into southwest Montana and Idaho.

The earthquake epicenters in these physiographic regions follow the same general pattern as the fault systems outlined. In western Washington there appears to be a relationship between these epicenters and the volcanic areas, while in western Oregon there appears to be no structural-epicenter relationships. The points of convergence of the various faults are the most active areas and also the areas of higher earthquake magnitude with activity noted from the early 1800's to the present.

The mountains of the Pacific Coast are moderate to steeply sloping with relief (base elevation to peak) varying from 1,000 feet to over 3,000 feet while inland, on the Columbia Plateau, the topography becomes moderate to gentle. In the northern Rockies and most of the southern Rockies, the mountains are moderate to steeply sloping with over 3,000 feet of relief.

In Alaska, the Taiga Coniferous Forest includes most of the western and all of the eastern central portions of the State, covering most of two large physiographic provinces, the Central Highland and Basin area and the Pacific mountains.

The extensive fault system found in Alaska is due to its being located at the apex of the eastern and western Circumpacific fault belts. Four mountain systems were formed as a result of this faulting and folding--the Pacific mountains along the southern coast, the Alaskan Range with the highest mountain on the North American Continent, Mt. McKinley, the White Mountains in the Yukon-Tanana highlands, and the Brooks Range of northern Alaska.

The most active earthquake areas are located at the flexture or apex of the fault systems along the southern coast and north of Fairbanks. Although normally slight in magnitude, the area is geologically very active with daily tremors commonly occurring. Massive earthquakes such as occurred in 1964, reflect the potential for major seismic occurrences.

Along the southern and southeastern coast, the topography of the forest area varies from low to high mountains with steep slopes and relief varying from 1,000 feet to over 3,000 feet.

In interior Alaska, the topography of the forest area varies considerably. The commercial forests are located in narrow bands along the river drainages and on the flat plains, while the noncommercial forests are found on the high and low open hills and mountains. Relief varies from 500 to 3,000 feet.

Along the southern coast, Cretaceous and Lower Tertiary age sediments predominate in the forest areas while to the southeast, Paleozoic sediments and intrusive granitic rocks of Tertiary and Mesozoic age predominate. In the interior, Quaternary aluvium covers the flats long the rivers while the upland areas have exposures of sediments and metamorphic rock varying in age from Precambrian to Tertiary. Small localized areas of Tertiary and Mesozoic age granitic intrusives are also found.

Minerals

Locatable mineral deposits are probably more pronounced in this biome than in any of the others. These deposits are principally of the vein type and closely associated with the Laramide orogeny of the Rocky Mountains, the Sierra Batholith, the Idaho Batholith, and the Pacific Coast disturbances. The deposits are distributed throughout the biome with the exception of few if any being found in montane coniferous forests in east-central Arizona and west-central New Mexico, Wyoming, and southeast Montana. However, this does not rule out the existence of deeply buried mineral deposits.

The leasables, other than petroleum, natural gas, and coal, again are the evaporite bedded type and appear to be found on the flanks of mountain ranges. The coal in this biome is of all types ranging from the anthracites through the bituminous to the lignites. There is less chance that large commercial leasable or locatable mineral deposits will be found in those portions of the biome in northeastern Washington, northeastern Oregon, Idaho, northwestern Montana, and central Arizona.

It could be that almost all types of the locatable minerals can be expected to be found in this biome. Following are the predominant ones: gold, silver, copper, lead, zinc, iron, manganese, chromium, cobalt, nickel, molybdenum, vanadium, tungsten, niobium, tantalum, tin, fluorspar, barite, gypsum, magnesite, and brucite. The leasables, other than petroleum and natural gas, are potash, borates, sulfur, coal, and phosphate.

Alaska needs separate treatment in describing mineral resources of this biome. Coal, one of the leasable minerals in this area, is primarily found in the northwestern part of Alaska. It ranges from anthracites through low volatile to high volatile subbituminous found principally in upper Paleozoic sediments.

The locatable minerals are found throughout the Taiga and Northwest Coastal coniferous forest areas. These minerals are found in close association with the fault systems throughout the area. The deposits are primarily of the fissure filling, replacement, or disseminated types. The gypsum, found in the northwest coastal area, is of the evaporite type. Some of the deposits, in particular tin, gold, silver, and platinum, are found as placer deposits along the rivers. In addition to the above, there are bedded barite deposits in the Cretaceous sediments in the northwest coastal area.

The locatable minerals of prominence in the Taiga and Northwest Coastal areas of Alaska are fluorspar, barite, gypsum, zinc, gold, silver, copper, lead, tin, platinum, molybdenum, nickel, chromium, iron, and mercury. The leasable minerals in this area are coal, oil and gas, and phosphate.

Soils

The soils in the coniferous forest biome range from the Inceptisols in the cool wet climate to the Mollisols in the very dry climate. Soils in most of the orders range in depth from very shallow to very deep, from sandy to clayey in texture, from very stony to non-stony, occur on topography that ranges from nearly level to very steep, and range from poorly drained to well drained. Criteria that seperate soils at the order level are very broad and are based on the weathering characteristics rather than behavior to management.

Inceptisols and Ultisols generally occur in the higher elevations and areas receiving larger amounts of precipitation. Ultisols have clay enriched subsoils, are acid in nature, and may have light or dark colored surfaces. Characteristics of the Inceptisols vary greatly. The soils in these two orders occur in northeastern California, western Oregon and Washington, adjacent to the Canadian border in northern Idaho and northwestern Montana, and south in the Rocky Mountains to central Idaho. A few Spodosols will be intermingled. Inceptisols are found throughout Alaska where mineral soils occur.

Permafrost conditions occur discontinuously through portions of the Taiga forests of interior Alaska. The soils of the river valleys and the lower side slopes of the mountains are covered with a thin to thick blanket of vegetative material that acts as an insulating mat. In most of interior Alaska, this mat provides protection and stabilizes the underlying soils

which are a frozen or a permafrost soil. When the vegetative cover is disturbed or removed, the permafrost is exposed, and during the moderate temperature short-duration summer period, the exposed permafrost melts at exceedingly high rates.

Alfisols occur in areas receiving less rainfall than the previous two orders. Therefore, the bare status is higher. Alfisols have a clay enriched subsoil and a grey to brown surface soil. The large areas of Alfisols are located on the east and west sides of the Sacramento Valley in California and areas on the east front of the Rocky Mountains in Montana, Wyoming, and Colorado.

Mollisols have a high base status, have a surface enriched in organic matter, and have dark colored surfaces. Mollisols are located in the southern Rocky Mountains in Utah and Arizona. The Mollisols range from cold to warm climate.

Entisols are young soils lacking diagnostic horizons. They occur in areas having recent deposits of alluvium, on very steep raveling slopes and on areas of recently stabilized sand dunes. These soils occur in western Colorado, northwestern New Mexico, and central Utah.

Aridisols are generally associated with the desert as they have prolonged dry periods. However, there are areas of Aridisols supporting coniferous forests in New Mexico and Arizona.

Water

The water resources of the coniferous forests provide most of the water needs for the western United States. These forest areas supply the major rivers and streams flowing from the forests and subsequently through the other biomes (grassland, desert, woodland-bushland). They are also largely responsible for recharge to the ground water aquifers of adjacent woodland-bushland, grassland, and desert areas. The generally higher elevation coniferous forests vary in annual precipitation received from as low as 10 inches in part of the Taiga Forest of Alaska to a high in excess of 150/ inches at some stations along the coastal areas of northwestern Washington and southeastern Alaska. Streams of the coniferous forests are largely perennial although some may be intermittent in regions where extended dry periods normally occur during certain seasons (i.e., along the coasts of Oregon and Washington during the summer). The coniferous forests are water surplus areas because of the large amounts of precipitation and provide generous quantities of high quality water which in many areas exceeds the demand.

Surface Water. The large quantities of surface water found in the coniferous forest biome occur as streams, rivers, lakes, reservoirs, springs, marshes, and pot holes. These water resources are used for power, industrial, municipal, agricultural, recreation, and fish and wildlife purposes. Natural lakes are an important part of the surface water resources of the coniferous forest biome.

Water yield from the coniferous forests is generally plentiful, ranging from about 5 inches annually in the southern Rocky Mountains to over 150 inches annually in parts of northwest Washington and southeastern Alaska. This water is yielded largely during the spring and early summer months in the higher elevations and in central Alaska where precipitation occurs mostly as snow. However, along the lower elevation coastal areas of northern California, Oregon, Washington, and southeastern Alaska where precipitation occurs during the winter, predominantly as rainfall, most of the runoff comes during the period of November through March.

The quality of most surface waters in the coniferous forests is good to excellent. Average dissolved solids (ions of sodium, calcium, chloride, etc.) generally are below 100 ppm. The sediment concentrations found in coniferous forest streams are generally low (usually less than 280 ppm).

Ground Water. Ground water supplies in the coniferous forests are generally adequate although not so important a source as in the grassland, desert, and woodland-bushland biomes. Because of the normal surplus of surface water, ground water use and demand in the forest areas is generally low.

The quality of ground water is generally good in the forests with a dissolved solid content that normally is less than 1,000 ppm.

Climate and Air

Significant climatic differences within the biome call for a separate analysis on a regionalized basis.

Rainy Coastal. Moist Pacific air moving in a west to east path results in high rainfall all along the coast. The dry season reaches its climax in July and August, after which the rainy season comes on gradually, reaching its peak in December. Average annual precipitation ranges from 30 to 40 inches in the San Francisco area, 60 to 140 inches in the Olympic Mountains of Washington, and 80 to 150 inches in the south central coast section of Alaska.

Temperatures range from a low of 15° below zero along the Alaska coast to 30° at San Francisco while high temperatures can reach into the 90's throughout the area. Mean daily temperatures range from 20° to 35° in January to 50° to 60° during July.

During winter months, the wind sometimes attains hurricane force along the ocean coast. In summer months, northerly winds prevail, especially in the daytime. Thunderstorms are infrequent and usually feeble along the western part of the area.

Interior Alaska. This part of Alaska is moist with severe winters. Precipitation varies from 7 inches in the upper Yukon Valley to 12 inches at Fairbanks and 16 inches in the Matanuska Valley. There are about two

months (June and July) when no snow falls and this tends to be the wettest time of the year with July averaging 3 inches of rainfall annually.

Temperatures range from 35° below zero in the Matanuska Valley and 75° below zero along the basin of the Yukon to a high of 90° in the Matanuska and 100° in the Yukon Basin. The mean daily temperatures vary from a low of -15° to -0°in January to 50° in July.

Winds are generally out of the east during the winter months at about 5 mph. During the short summer season, winds are out of the west bringing moist maritime air in from the Bering Sea. During the summer months, thunderstorm activity takes place from 5 to 10 days each year.

The daily hours of growing season sunshine in the Interior of Alaska are as varied as the rainfall and temperature differences. The lower latitudes receive 16 hours of sunshine a day during June while the northern latitudes receive 24 hours. However, there are nearly as many cloudy days as clear days in the course of a year which affects the incoming solar radiation during summer months.

<u>Mountain Association</u>. The climate within this area is directly related to elevation--the higher it is, the colder and wetter the climate.

Precipitation at the lower levels generally averages about 16 inches per year. The higher elevations are quite different, with the Sierras in California receiving 50 inches, the Cascades 90 inches, and the Rockies 30 inches. Average January precipitation varies from 8 inches along the Sierras and Cascades to 1 to 3 inches in the Rockies and from 1 inch or less along the Sierras and Cascades to 2 to 3 inches in the Rockies during July.

Average daily minimum temperatures during January range from 20° at the lower elevations to 0° at the higher elevations. Maximum temperatures during July average 85° at the lower elevations to 70° at higher elevations. The mean daily temperatures average about 10° warmer during January and 10° colder during July.

Wind directions and velocities are subject to topography and considerable convective activity, especially during the summer months. At the summits of the mountains, the winds are generally from the west and are frequently very strong in the winter and spring.

There is considerable thunderstorm activity in this mountainous country--especially over Colorado and New Mexico--where the incidence (50 to 70 per year) of thunderstorm activity is exceeded only in Florida and the Gulf Coast.

Vegetation

Coniferous trees are the predominant form of vegetation covering extensive areas ranging from the Pacific Coast, including Alaska, to the grasslands in the east. The identifying life-form is the needle-leaved evergreen tree, especially the spruces, firs, and pines which form a relatively continuous canopy over the forest floor. Thus, a dense shade exists the year around, often resulting in poor development of shrub and herb layers. However, the continuous blanket of chlorophyl present the year around results in a fairly high annual production rate.

The composition of the forest vegetation is influenced to a large extent by elevation resulting in four basic vegetational zones. Proceeding upward from the lowlands, these include the woodlands, forest, subalpine forest, and alpine meadows. Due to the comparatively high rain or snowfall, a profusion of water bodies and courses are distributed over the forest supporting an abundant variety of aquatic species of plant life. In addition to the actions of man, natural forces such as bark beetles, defoliating insects, disease, and fire exact annual losses to the vegetation. However, such outbreaks are part of a continuous cycle of development to which the coniferous forest ecosystem is adapted through rapid plant establishment and succession.

The harvesting of timber to provide wood products characterizes most of the biome, historically as well as presently. The forest vegetation provides aesthetic and recreational values and acts as a soil stabilant in protecting extensive watersheds for man's enjoyment and use. The vegetation also provides shelter, protection, and food to the many forms of wildlife that dwell in the forest. Over time, the area supporting forest vegetation has been reduced in some areas for agricultural crop production or urban development.

There are three geographic areas which comprise the coniferous forest:

The Montane Forest is scattered over extensive areas in the mountainous regions of the western United States. In the lower elevational zones the primary species consist of douglas-fir, engelman spruce, ponderosa pine, lodgepole pine, and aspen. In the higher zones, subalpine and alpine conditions exist with grassland meadows interspersed with dense stands of subalpine firs and engelman spruce. In addition to being an important timber producing region, it embraces large areas devoted to recreation and wilderness use.

The Coastal Coniferous Forest is a narrow belt extending along the coast from northern California to southeastern Alaska and is characterized by lush vegetation due to the high annual rainfall. Douglas-fir, redwood, hemlock, western red cedar, and sitka spruce are the predominant tree species and collectively constitute one of the most productive timber growing regions in the world. A dense vegetal understory is made up primarily of mosses, salal, and salmonberry.

The Taiga Forest covers the vast area of interior Alaska and supports white spruce, black spruce, paper birch, balsam poplar, and aspen. The permafrost and high water table levels are important determinants affecting their distribution. Interspersed are areas comprising sedges and grasses formed following the succession of lake to bog. The entire forest is essentially virgin in nature and fires constitute the primary destructive force to which the vegetation is subjected.

Animals

Wildlife - Terrestrial. Terrestrial wildlife of the coniferous forests can best be presented by the three major forest types which they inhabit. Taiga forests typically have a thick duff layer and decay takes place slowly. The soil may contain a fair population of small organisms but comparatively few large ones. Most animals are shy and retiring. They utilize the dense evergreen growth as cover and for protection in winter weather. They can tolerate cold winters with much snow. The herbivores are largely browsers. Some, such as the moose, elk, snowshoe hare, and grouse, depend at least in part on broad-leaved plant communities found in burns or natural openings, along streams, etc.

The Taiga has an enormously important seasonal cycle conspicuous in the dormancy of its invertebrates and of many vertebrates, and in the spring influx and autumn departure of migratory birds. Outbreaks of certain insects, particularly bark beetles and defoliators, result in destruction of large areas of forest. About 50 species of insects are important. The spruce budworm and the tent caterpillar are dominants and important everywhere.

Found throughout nearly the entire biome are: wolverine, lynx, red squirrel, and snowshoe rabbit. The larger animals progressively drop out southward on the mountains. The moose and, in the east, the white-tailed deer are widely distributed. The woodland caribou formerly was abundant in the east where it was important to native tribes. Smaller typical species include the porcupine, woodchuck, weasels, snowshoe rabbit, northern flying squirrel, marten, red squirrel, chipmunk, and various mice and shrews.

Wildlife - Aquatic. Inland waters of the coniferous biome that do not empty directly into the sea are characterized by high quality, low temperatures, and a fair grade of aquatic food.

High elevation streams support trout, whitefish, and sculpin populations. Lower streams support chub, carps, dace, and suckers mixed with populations of salmonids. Other common fish are black gass, sunfish, catfish, pike, and minnows.

West coast and Alaska streams produce the anadromous steelhead and five commercially important species of salmon: the chinook, sockeye, chum, pink, and coho. Migratory populations of coastal cutthroat trout are present in many coastal streams from California to Bristol Bay, Alaska. Other important species are striped bass, shad, sturgeon, etc.

Threatened or Endangered Wildlife. Threatened (T), endangered (E), peripheral (P) terrestrial species and species of undetermined status (U) in the coniferous forest include:

- (T) Kaibab squirrel, restricted range, Arizona
- (T) Glacier bear, southern Alaska
- (T) Grizzly bear, northern Rocky Mountains
- (P) Mountain caribou, in U.S. Pacific Northwest
- (U) Pine marten, northern U.S.
- (U) Fisher, northern U.S.
- (U) Wolverine, northern U.S.
- (U) Canada lynx, northern U.S.

Threatened (T) or endangered (E) fish in the biome include:

- (E) Arctic grayling, Montana
- (E) Greenback cutthroat trout, Colorado
- (T) Little Kern goldentrout, California
- (T) Olympic mudminnow, Washington

Domestic Livestock. Livestock grazing occurs largely on the mountain meadows interspersed as small vegetative islands throughout the biome and in the open stands of timber where forage species grow among the sparse stands of trees.

Both cattle and sheep graze these areas, with cattle generally concentrating on the lower elevations and sheep on the higher elevations. The upper elevations on into the subalpine and alpine zones are grazed exclusively by sheep. Some horse use occurs in connection with recreation activities such as riding and pack trips, but this is relatively minor overall. Most livestock use occurs between June 15 and October 1.

Over the years, livestock use has declined on the coniferous forests because of withdrawal of portions from grazing for watershed protection purposes. This trend could continue.

Human Settlement and Land Use

Montane Coniferous. Most of white man's early settlement in the Montane subbiome began with search for gold and silver. Some were successful and towns sprang up quickly. Many early mining settlements have either disappeared or are ghost towns today. Several counties in Colorado, Idaho, Oregon, and Washington had the greatest populations prior to 1920 and have since decreased. Large national forests and parks in the area have virtually no permanent year around habitation.

Forest products, mining, agriculture, and tourism are major sectors in the economy. Lumbering and livestock grazing occur generally throughout the biome. Ranches or small farms usually are located along streams or river valleys where small areas may be cultivated. Mining, while not as extensive as lumbering or grazing, occurs in some locations and provides significant income and employment.

Recreation-tourism is growing rapidly in importance. In areas with outstanding resources such as the Yellowstone Park area or Aspen, Colorado, tourism is the mainstay for local communities. The Montane forest has very high general recreational potential and is significant on a national basis for this land use. The acreage of designated wilderness and undeveloped lands is substantial.

Communities tend to be small and reflect logging, ranching, or mining which may occur in the area. Southern portions of the biome retain, in part, the culture of early Spanish settlement.

Coastal Coniferous. Most portions are rough and mountainous and the coastal subbiome is extremely productive for forestry purposes--so much so that lumbering and wood products industries play a dominant role in income and employment.

The Seattle and Portland metropolitan areas are located in a broad valley extending from Puget Sound to central western Oregon. The same valley also contains the bulk of intensive agricultural land within the region. Dairying is a major agricultural use. Low cost hydroelectric power, abundant water resources, and ports have contributed to industrial growth of urban areas. Typical settlements such as those outside of the Puget Sound or the Willamette Valley are small and center around lumbering or sawmilling.

Forested lands and abundant wildlife and fish resources provide very significant recreation potentials. Close proximity to the Pacific Ocean adds to recreational diversity. The climate, which includes long periods of rain or fog, is a limiting factor for year around recreational use.

Except for limited urban areas such as Valdez and Juneau, settlement in the southeastern Alaska portion is much less developed than that of the lower 48.

Taiga Coniferous. This vast region is virtually uninhabited--only limited settlement occurs outside of the Anchorage and Fairbans urban vicinities. Remote white and aboriginal settlements are located along major river drainages and very limited road systems. Population growth has been rapid; a 1970 Alaska population of 300,382 represents a 33 per cent increase. This represents, however, only 0.5 person per square mile of land area on a state basis.

Aboriginal peoples in the subbiome are highly dependent on fish and wildlife for subsistence. Modern civilization, e.g., life styles, firearms, snowmobiles, etc., have had a tremendous impact on their culture.

A primary land use in the Taiga is the harvesting of fish and game by aboriginal people and, more recently, by the whites. The latter is more a recreational use than necessity. Transportation by road is extremely limited and air travel is used very extensively in the interior. Most areas remain wild, remote, and inaccessible and represent one of the largest remaining contiguous wilderness areas in the world.

Mining has been the only other appreciable land use in the area--gold mining early in this century and more recently other minerals and oil and gas exploration and development. Oil on Alaska's North Slope and a proposed pipeline through the Taiga could drastically affect associated land uses.

Utilization of the forest resources is limited to local consumption around urban areas (Anchorage-Fairbanks) and isolated settlements. Most of the forest resources are noncommercial under current economics and technology due to inaccessibility and limited demand.

The majority of lands are presently in public ownership. Future jurisdiction will depend on relative resource values and the interaction of the Alaska Statehood Act (State selection) and the Alaska Native Claims Settlement Act (PL 92-203).

Climatic extremes severely limit human habitation and land uses. Severe winter temperatures, short summers, and wide occurrence of permafrost dictate a careful evaluation of all intensive land uses which may be proposed.

Aesthetics

The coniferous forests provide what probably are the most spectacular scenic values of all the biomes. The land form varies from the rounded foothills of the Cascades to the angular peaks of the Rockies, from relatively flat mesas and basins to nearly vertical canyons.

Textures vary from the relatively soft continuous forest canopy of the west slopes of the Cascades to the broken patches of trees among the rocks at the higher elevations of the Montane regions. Colors generally reflect the green of the conifer cover. However, in the higher elevations, as the vegetation becomes more sparse, the colors of the exposed rock and soil become apparent.

Lines are probably more obvious in the natural environment of the coniferous forest biome than in any other. There are many abrupt changes in vegetation types caused by a change in soil, an avananche path, an intrusion of rock, etc. There may be lines in the sharp angular surface of the exposed rock.

Scale, though easily defined, may become almost overpowering in some areas. The overall effect on people varies with the background of the individual observer. To some, mountains are a frightening experience; to others, they are a much desired place to be. The wide variety of forms, textures, colors, and lines is what makes the scenic values in the coniferous forest biome interesting, while vastness of scale and distance can bring an awesome feeling of isolation.

Geological Human Interest Values

In the Montane coniferous forest are found geologically interesting areas such as Mount McKinley, the highest peak in North America, and glaciers; features left by glaciation such as morains, lakes, U-shaped valleys; erosion features like canyons, pinnacles, peaks, and mudflows; volcanic features such as active and dormant volcanoes and lava flows, eroded ash beds, dikes, exposed plugs, calderas, hot springs, and geysers.

The Taiga coniferous forest is oriented to evidences of glacial action. Such structures as morains, drumlins, glacial lakes, and other features occur along with features associated with permafrost and its actions such as pingos, thaw lakes, beaded drainages, etc.

The Northwest Coastal Coniferous Forest is edged with an interesting eroded coastline of natural arches, isolated rock islands, sand dunes, and steep cliffs. The higher sections contain canyons, volcanic features, caves, and faulting evidence.

Archeological Values

Native Americans generally did not live in the coniferous forests. Instead, they lived along water courses and used the forests for hunting and gathering. The peoples of the deserts and grasslands used the coniferous forests within traveling range.

The Taiga coniferous forest is fairly synonymous with the Western Sub-Arctic Culture Area. The early tradition in this area is both Old Cordilleran and Big Game Hunting, followed by the Northwest Microblade tradition of people who lived by hunting caribou, elk, buffalo, and fishing. The Microblade tradition probably provided the core for the Denetasiro tradition which became the Athabascan-speaking Indians of contact times. Sites are mostly campsites and occasional rock shelters along streams and lakes and on ridge tops.

The northwest coastal coniferous forest was the home of the salmon-fishing-oriented Northwest Coastal Cultures. Based on the Old Cordilleran Tradition and the Northwest Coastal Tradition, it quickly evolved to become very distinctive with its great use of wood and elaborate art work. Village sites were along the streams and consisted of either pit or surface houses. Occasional rock shelters and some campsites are found away from the streams.

5. Tundra Biome

The tundra biome encompasses all of the areas north and west of the Taiga forests in Alaska. Basically, this treeless zone includes the Brooks Range and flatlands to the north as well as the Seward Peninsula on to the Aleutian Island chain. The extent of this biome is mapped in figure II-25.

While virtually all of the tundra region of northern Alaska is currently in Federal ownership, State land selections, especially in potential oil-rich areas, and native claims surrounding coastal settlements are likely to change this pattern over the next two decades. Oil and gas reserves and resources are large in portions of this region. Exploration activities have been heavy in recent years. However, environmental problems related to field development and pipeline construction have delayed production to date.

Ecological Interrelationships

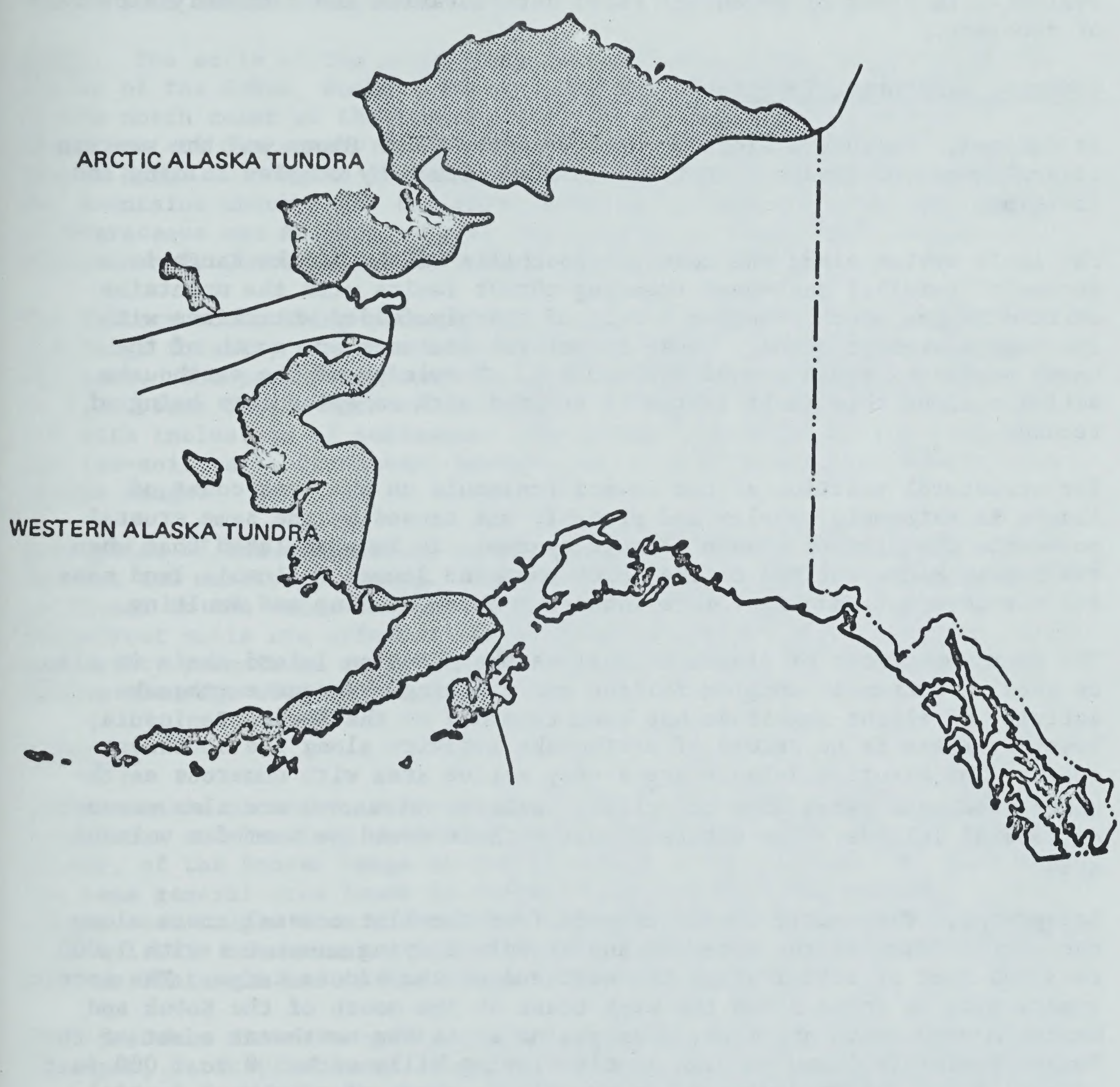
Temperature exerts a powerful limiting effect on the tundra ecosystem and relatively few kinds of organisms have become successfully adapted. The permanently frozen subsoil restricts that soil which is available for producing the living components, and it also restricts the infiltration of water for recharge of ground water and stream flow. There is a minimum of water which goes through living plants and animals and through the soil mantle. A large part of the water cycle consists of surface runoff and surface storage within the tundra ecosystem.

Solar radiation is unique in the tundra as light is almost continuous throughout the short growing season. It is intense and high in ultraviolet rays. Characteristically, cold, desert-like, drying summer winds produce high rates of evaporation and transpiration. Thus, water often is a critical factor.

Production of the terrestrial and aquatic ecosystems is dominated by a short growing season of 45 to 90 days. The first 2 or 3 weeks of the growing season and the previous summer stand reserves are critical to the energy flow. The food chain is relatively short, and any radical change in numbers at any of the three tophic levels has violent repercussions on the other levels because there is often little in the way of alternate choice of food.

Even though ecologically simple, the tundra ecosystem is extremely delicate and responds dramatically to seemingly minor perturbations. This response is, in part, the result of increased energy flow into the upper substrata as the insulating covers of vegetation and peat are grazed, physically disrupted, or removed. This results in acceleration of thaw and rapid erosion of the underlying ice-rich permafrost.

Figure II-25. Tundra Biome



Tundra ecosystems are a complex mosaic of vegetation, soil, micro-relief and aquatic environments. The flora and fauna and scenic attractions are fairly well known, but ecosystems have not been fully studied. The impacts of a single action on a specific area may be foreseen but knowledge of cumulative effects is lacking. Therefore, any proposed actions must be evaluated in terms of potential rapid deterioration and extremely slow rate of recovery.

Geology, Landforms, Topography and Soils

As defined, the tundra biome occurs along the North Slope and the western coastal areas of Alaska. This is an area marked by complex folding and faulting.

The fault system along the northern foothills of the Brooks Range is a series of parallel east-west trending thrust faults with the mountains shifted to the north, causing a belt of sharply folded anticlines with the same east-west trend. These structural features are south of the known producing areas around Prudhoe Bay. Knowledge of the earthquake activity along this fault system is limited with no epicenters being of record.

The structural position of the Seward Peninsula on the west coast of Alaska is extremely complex and probably was caused by the same crustal movements that formed Alaska's fault system. It is postulated that when the Brooks Range shifted to the north that the Seward Peninsula land mass did not move but underwent more intense complex folding and faulting.

The southwest coast of Alaska as well as the Aleutian Island chain is also an area of extremely complex folding and faulting. Recent earthquake activity of slight magnitude has been recorded on the Seward Peninsula; however, there is no record of earthquake activity along the southwest coast. The Aleutian Islands are a very active area with numerous earthquakes recorded along the coastline; active volvanoes are also present on several islands. The entire Aleutian chain would be termed a volcanic area.

Topography. The Arctic tundra extends from the flat coastal areas along the Arctic Ocean to the moderate and steeply sloping mountains with 1,000 to 3,000 feet of relief along the west end of the Brooks Range. The Arctic tundra also is found along the west coast at the mouth of the Kobuk and Noatak Rivers, which are flat, open plains as is the northwest coast of the Seward Peninsula. Low to high gently sloping hills with 500 to 1,000 feet of relief are the predominant topographic features of north and central areas of the Seward Peninsula while the southern coast has predominantly low gently sloping mountains with 1,000 to 3000 feet of relief. The steeply sloping mountains along the west end of the Peninsula lack vegetative cover, the tundra being restricted to a few intermountain valleys and the gently sloping hills or flat areas near the coast.

The topography of the western tundra varies from the flat plains along the Yukon and Kuskokwim Rivers to the high moderately sloping mountains with over 3,000 feet of relief located along the southwestern coast. In the Aleutians, topography ranges from smooth, gently sloping plains along the northern coastal areas to the high mountainous areas; relief also varies from island to island.

Soils. The soils of the north slope coastal areas, the areas around the mouths of the Kobuk, Noatak, Yukon, and Kuskokwim and other rivers as well as the north coast of the Seward Peninsula and north coast of the Aleutians are Quaternary sediments, while the sediments exposed in the Brooks Range and on the Seward Peninsula are mainly of Upper Paleozoic age. The mountains which reach the ocean along the southwest coast are composed of Cretaceous age sediments while the islands of the Aleutian chain are predominantly Quaternary and Tertiary age volcanic rocks.

The factors controlling permafrost, as outlined previously in regard to the Taiga forests, also occur in the tundra biome but are much more significant. The permafrost zone along the northern coastal areas is as much as 2,000 feet thick, much of it being ice rich or in reality a layer of ice with inclusions of sediments. The permafrost thins to the south and the ice-soil ratio decreases; however, it is continuous far south of the Brooks Range.

Disruption of the equilibrium can have serious effects with rapid soil erosion and massive slumping. Sensitivity to such damage is directly proportional to the water content of the permafrost soil. Dry, gravelly permafrost soils are affected little by disturbance induced thawing, while wet, silty permafrost soils (called "ice-rich") are very susceptible to oozing slumpage when thawed.

Minerals

The leaseable minerals, coal and phosphate, are found primarily in the Cretaceous and Tertiary sediments on the north and south slopes, respectively, of the Brooks Range in Arctic Alaska. North Slope coal lies in the same general area found to contain large oil and gas reserves. The Arctic coal ranges from anthracites through subbituminous to medium and high volatile bituminous. Sulfur is found near the western end of the Alaskan Peninsula and is the result of volcanic activity.

The locatable minerals--gold, copper, platinum, silver, lead, zinc, tin, fluospar, barite, antimony, iron, molybdenum, mercury, and tungsten--are to be found in the Brooks Range, western Alaska, and Alaskan Peninsula to Seward Peninsula. These are related to the Paleozoic sediments.

Water

The major water resources of the tundra biome in northern and western Alaska are the streams, rivers, and many natural bodies such as lakes,

ponds, and marshes. Presence of permafrost causes ground water supplies to be limited because of restrictions to recharge. The surface waters of the tundra biome drain seaward and empty directly into the Bering, Chukchi, and Beaufort Seas.

Surface Water. The surface water resources of the tundra biome include streams, rivers, ponds, lakes, marshes, bogs, and swamps. Surface waters are used for domestic, municipal, recreation, and fish and wildlife purposes. Natural water bodies such as lakes, ponds, and marshes are important to recreation and fish and wildlife uses.

Average annual precipitation ranges from less than 10 inches to 30 inches. Average annual runoff varies with annual precipitation. However, little is known about actual water yields in the tundra areas. Due to low potential evapotranspiration, the tundra is a water surplus area.

The quality of most surface waters is good except in two situations: (1) the sediment content of glacier-fed streams and rivers is high; (2) surface waters that derive from extensive swamp areas are usually high in organic and iron content because the drainage of such areas is often restricted by impermeable subsurface materials, including permafrost.

Ground Water. Little is known about the ground water resources of the tundra biome. Generally, in areas underlain by permafrost, ground water is extremely difficult to obtain. The quality of ground water varies in the tundra areas with some low in dissolved solids (less than 200 ppm) while others are high in dissolved iron content.

Climate and Air

The tundra biome is characterized by a mild polar climate in the north and a rainy climate with severe winters in the south. During winter, the Arctic high pressure system brings a dry cold flow of air to the northern part of the biome. At the same time, this high pressure system picks up moist air from the Gulf of Alaska and deposits it along the western coast of Alaska. In the summer, a low pressure system develops off the west coast of Alaska in the Bering Sea which results in a flow of moist air over the coastal (except the north coast) and interior sections of Alaska, resulting in the months of July, August, and September being rather wet. The average annual precipitation ranges from 8 inches along the Arctic coast to 16 inches at Nome, 20 inches at Bethel, and 60 inches at Kodiak.

Temperatures are influenced by latitude and the movement of air in relationship to the land mass. In the north during January, the air flow is from a cold continental air mass, causing temperatures to average 10° below zero. During this period, the mean annual temperature warms progressively to the south, where at Kodiak the temperature in January averages 30° above zero. Average July temperatures vary very little--from 40° in the north to 50° in the south.

The growing season fluctuates with latitude. The western coast area averages about 100 days a year. Under the influence of prolonged daylight, however, vegetation makes rapid growth.

Vegetation

Vegetation in the tundra biome structurally is simple and is dominated by a single growth form of low statured grasses and sedges. Herbaceous and woody vegetation such as willows and birch also are present but consist only of species which are similarly low statured or even prostrate.

Essentially, in arctic grassland, the tundra is a treeless area with many lichens and mosses. During the short growing season, temperature often is near the lower limit of biological activity. Nearly all plants are perennial and annual production is low. Total annual increment of bound energy into the ecosystem is small.

A thick, spongy mat of living and undecayed vegetation, often saturated with water and interspersed ponds, characterizes the low tundra when not frozen. The high tundra on steep slopes may support only a scanty growth of lichens and grasses.

The vegetation of the tundra forms an insulating layer which is critical to the stability of the ecosystem. Removal of vegetation can result in degradation of permafrost leading to erosion and thermokarst. Thus, even the microstructure of vegetation is very important.

Animals

Wildlife - Terrestrial. Due to low temperatures, short growing seasons, low precipitation, and intermittent freezing and thawing of the thick, spongy mat of low tundra vegetation, bacterial action is very slow. Even the high tundra may be bare except for scanty growth of lichens and other low plants. Yet many mammals and birds remain throughout the year, including caribou, musk ox, arctic hare, arctic fox, lemming, and ptarmigan. Violent oscillations in population density of some animals are characteristic, e.g., lemmings and the dependent owls and jaegers that prey on them; also, the snowshoe hare and lynx cycles. Other characteristic mammals of the arctic slope and north of the Brooks Range include the polar bear, arctic wolf, wolverine, Alaska red fox, marmots, Parry's ground squirrel, red-backed mouse, several voles, and shrews.

Bird life is remarkable for its vast abundance in the brief summer. Waterfowl especially gather in large numbers to nest and rear their young. Few birds remain in winter when even the snowy owl may move southward. Willow ptarmigan usually are present year-round.

An outstanding feature of the low tundra community is the great number of dipterans (fly family). Most hibernating insects withstand temperatures down to -50° F. Mosquitoes, gnats, flies, beetles, bugs, bumblebees,

wasps, moth larvae, spiders, and mites may overwinter in plant tufts and under stones and driftwood. Aquatic insects and larvae either burrow into mud or pass the winter in the egg stage.

The uplands are inhabited by caribou (except in winter), Dall's sheep, some grizzly bears, marmot, ground squirrel, rock ptarmigan, horned lark, and lapland longspur. There are no reptiles and no known amphibians.

Wildlife - Aquatic. The tundra biome lakes and ponds and bogs do not support large populations of aquatic life due to lack of minerals and nutrients. Resident fish grow slowly but due to isolation may grow to a large size because of age. Characteristic fish are chars, grayling, and whitefish. The chars are lake trout (mackinaw) and arctic char. The arctic grayling is abundant and well distributed in tundra waters. The sheefish inhabits the major rivers. Anadromous fish that spend part of their life cycle in tundra streams are chum and pink salmon. These fish enter streams, deposit eggs, and the hatched fry migrate quickly to the ocean. Sockeye salmon use streams with lakes in headwaters. Fry migrate from streams and spend one or two years in a lake prior to sea migration.

Threatened or Endangered Wildlife. Endangered species include the arctic peregrine falcon, which breeds above the Arctic Circle, and the Aleutian Canada goose, which nests on some of the islands in the Aleutian chain. The status of the polar bear, pine marten, wolverine, and Canada lynx is undetermined. The musk ox, once eliminated in Alaska, has been reintroduced. It is not clear whether the reintroduction will be successful.

Domestic Livestock. The only domestic livestock supported by the Alaska tundra are reindeer herds. These fit the term "domestic" only in the sense that they are loosely herded and an attempt is made to keep them separated from the wild caribou herds. Reindeer are completely compatible with caribou and will join the caribou and revert to the wild state if allowed to mingle.

Reindeer were introduced to Alaska from Lapland to provide a reliable source of meat for the Eskimos and make them less dependent on wild species for food supplies. By law, only native Eskimos are permitted to utilize reindeer on a managed herd basis. Management and control are generally by family units and grazing is year-long.

Human Settlement and Land Use

Harsh conditions of the tundra biome have limited settlement to small villages along the coastline and major rivers. Most inhabitants, aboriginal and white alike, are dependent on the surrounding natural resources for subsistence or livelihood.

Eskimos, who make up about one-half of the State's native population, live along the Bering and Arctic seacoasts. The Aleutian people are the smallest native group and have traditionally lived along the Alaskan Peninsula and Aleutian chain of islands.

The native Alaska population shows a 27 percent increase from 1950-1960 and a 19.5 percent increase during 1960-1970. Improved health care has partially arrested high infant death rates, but the native population continues to have various health problems above the national norms.

Fishing and hunting have historically been a sole means of survival for natives on the tundra. Incomes and cost of living for immigrants or whites is very high compared to the lower 48 states. The Eskimo, trying to live according to higher white standards on an Eskimo income, is in a serious predicament. Public assistance to native peoples represents a significant portion of their cash income, and employment opportunities are poor. Conflicts between native culture and modern society present a thorny problem. Many native peoples wish to adopt certain aspects of modern society, including a higher standard of living, but differences between cultures make the transition difficult.

Minerals and mining have been a primary thrust for exploration and development of the tundra region. Initially, gold discoveries on the Seward Peninsula resulted in a flurry of development which was followed by intensive prospecting throughout the region. This resulted in the discovery and mining of numerous mineral deposits in addition to gold. More recently, sizable oil and gas discoveries at Prudhoe Bay have been made.

Tourism is expected to be a future important source of income which would utilize the area's vast undeveloped natural resources for recreational purposes. Hunting and fishing are steadily increasing aided by the use of small aircraft and all-terrain vehicles.

The tundra is unproductive in an agricultural land use sense due to extremely harsh winters and short growing seasons.

Aesthetics

The land form in the tundra biome is the low rolling, nearly flat form common to the grasslands. The texture is the extremely fine soft texture of the tundra itself and almost indistinguishable except at very close range.

Color is the soft monotone gray-green of the vegetation and is interrupted only by an occasional stream meandering through on its way to the sea, and lines are almost nonexistent in any form. Scale, as in the grasslands, is very difficult to define. There is almost nothing vertical to relate to.

Altogether the tundra does not hold a great deal of interest to the seeker of scenic value. Yet, because it is so plain and so much the same, almost any disruption or intrusion immediately becomes the focal point for the observer.

Geological Human Interest Values

Features of geological interest are limited and similar to those discussed regarding the Taiga coniferous forest. There are the normal effects of glaciation, coastal erosional features, and the results of permafrost and other extreme freeze action on the land surface such as pingoes, the small raised islands of ice. In the Aleutian chain are the evidences of volcanic construction. Surprisingly, there are two small deserts along the Taiga to tundra transition zone that are replete with sand dunes.

Archeological Values

The tundra biome is basically synonymous with the Eskimo and Aleut culture areas, or the Arctic Tradition. The Aleuts, linguistically related to the Eskimo, live on the Aleutian Island chain. Because of their proximity, western Alaska continually received stimuli from the Old World.

There are evidences of both the Old Cordilleran Tradition and the Big Game Hunter Tradition in earliest Alaska. This was followed by the Northwest Microblade Transition, characterized by numerous microblades struck from conical cores. The next tradition, known as the Arctic Small Tool Tradition, is characterized by a unique style in fine pressure-flaked flint and small tools. Last to be found is the Eskimo Tradition, which probably began some 4,000 years ago. All of the traditions lived along the seacoast for the most part; all lived by hunting large sea animals, catching fish, and hunting caribou and other animals inland. Many of the better gravel bars and sand pits were occupied by pit and surface houses for thousands of years, each beach strand frequently representing a different time period or culture.

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CHAPTER III

PROMULGATION OF LEASING AND OPERATING REGULATIONS

A. PROPOSED REGULATIONS

As stated in chapter I, the proposed action involves the leasing of federally owned lands for the exploration and development of geothermal resources pursuant to the Geothermal Steam Act of 1970 (complete text of Act follows). This environmental impact statement pertains to the promulgation of leasing and operating regulations, pursuant to which the program would be administered, and the subsequent leasing of federally owned geothermal resources of three specific areas--Clear Lake-Geyers, Mono Lake-Long Valley, and Imperial Valley, all in California. The presentations included in this chapter primarily relate to the proposed leasing and operating regulations. However, they also reflect the overall considerations within which the specific evaluations of potential environmental impacts are included in Chapter V for the three areas proposed for leasing. This relationship will be reflected throughout both chapters in terms of both the general regulations and the specifics for the individual areas.

Proposed leasing and operating regulations to implement the Geothermal Steam Act were published in the Federal Register on July 23, 1971, revised and published in the Federal Register on November 29, 1972, and further revised and published in the Federal Register on July 23, 1973, and corrected in the Federal Register of August 8, 1973. Proposed unit plan regulations were published in the Federal Register on May 3, 1972, revised and published in the Federal Register on November 29, 1972, and as further revised and published in the Federal Register on July 23, 1973. These regulations provide a framework for leasing, exploration, development, and utilization of geothermal resources on public lands, consistent with multiple-use management objectives.

The complete text of the July 23, 1973, regulations are included in this section and in Volume III, Appendices A and B. Copies of the earlier proposed regulations and related comments are included in Volume III, Appendices C, D, and E.

Public Law 91-581
91st Congress, S. 368
December 24, 1970

An Act

84 STAT. 1566

To authorize the Secretary of the Interior to make disposition of geothermal steam and associated geothermal resources, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Geothermal Steam Act of 1970". Geothermal Steam Act of 1970.

SEC. 2. As used in this Act, the term— Definitions.

(a) "Secretary" means the Secretary of the Interior;

(b) "geothermal lease" means a lease issued under authority of this Act;

(c) "geothermal steam and associated geothermal resources" means (i) all products of geothermal processes, embracing indigenous steam, hot water and hot brines; (ii) steam and other gases, hot water and hot brines resulting from water, gas, or other fluids artificially introduced into geothermal formations; (iii) heat or other associated energy found in geothermal formations; and (iv) any byproduct derived from them;

(d) "byproduct" means any mineral or minerals (exclusive of oil, hydrocarbon gas, and helium) which are found in solution or in association with geothermal steam and which have a value of less than 75 per centum of the value of the geothermal steam or are not, because of quantity, quality, or technical difficulties in extraction and production, of sufficient value to warrant extraction and production by themselves;

(e) "known geothermal resources area" means an area in which the geology, nearby discoveries, competitive interests, or other indicia would, in the opinion of the Secretary, engender a belief in men who are experienced in the subject matter that the prospects for extraction of geothermal steam or associated geothermal resources are good enough to warrant expenditures of money for that purpose.

SEC. 3. Subject to the provisions of section 15 of this Act, the Secretary of the Interior may issue leases for the development and utilization of geothermal steam and associated geothermal resources (1) in lands administered by him, including public, withdrawn, and acquired lands, (2) in any national forest or other lands administered by the Department of Agriculture through the Forest Service, including public, withdrawn, and acquired lands, and (3) in lands which have been conveyed by the United States subject to a reservation to the United States of the geothermal steam and associated geothermal resources therein. Leases.

SEC. 4. If lands to be leased under this Act are within any known geothermal resources area, they shall be leased to the highest responsible qualified bidder by competitive bidding under regulations formulated by the Secretary. If the lands to be leased are not within any known geothermal resources area, the qualified person first making application for the lease shall be entitled to a lease of such lands without competitive bidding. Notwithstanding the foregoing, at any time within one hundred and eighty days following the effective date of this Act: Bids. Conversion.

(a) with respect to all lands which were on September 7, 1965, subject to valid leases or permits issued under the Mineral Leasing Act of February 25, 1920, as amended (30 U.S.C. 181 et seq.), or under the Mineral Leasing Act of Acquired Lands, as amended (30 U.S.C. 351, 358), or to existing mining claims located on or prior to September 7, 1965, the lessees or permittees or claimants or their successors in interest who are qualified to hold geothermal 41 Stat. 437. 61 Stat. 913.

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leases shall have the right to convert such leases or permits or claims to geothermal leases covering the same lands;

(b) where there are conflicting claims, leases, or permits therefor embracing the same land, the person who first was issued a lease or permit, or who first recorded the mining claim shall be entitled to first consideration;

(c) with respect to all lands which were on September 7, 1965, the subject of applications for leases or permits under the above Acts, the applicants may convert their applications to applications for geothermal leases having priorities dating from the time of filing of such applications under such Acts;

Acreage limitation.

(d) no person shall be permitted to convert mineral leases, permits, applications therefor, or mining claims for more than 10,240 acres; and

(e) the conversion of leases, permits, and mining claims and applications for leases and permits shall be accomplished in accordance with regulations prescribed by the Secretary. No right to conversion to a geothermal lease shall accrue to any person under this section unless such person shows to the reasonable satisfaction of the Secretary that substantial expenditures for the exploration, development, or production of geothermal steam have been made by the applicant who is seeking conversion, on the lands for which a lease is sought or on adjoining, adjacent, or nearby Federal or non-Federal lands.

(f) with respect to lands within any known geothermal resources area and which are subject to a right to conversion to a geothermal lease, such lands shall be leased by competitive bidding: *Provided*, That, the competitive geothermal lease shall be issued to the person owning the right to conversion to a geothermal lease if he makes payment of an amount equal to the highest bona fide bid for the competitive geothermal lease, plus the rental for the first year, within thirty days after he receives written notice from the Secretary of the amount of the highest bid.

Lease provisions. Royalties.

SEC. 5. Geothermal leases shall provide for—

(a) a royalty of not less than 10 per centum or more than 15 per centum of the amount or value of steam, or any other form of heat or energy derived from production under the lease and sold or utilized by the lessee or reasonably susceptible to sale or utilization by the lessee;

(b) a royalty of not more than 5 per centum of the value of any byproduct derived from production under the lease and sold or utilized or reasonably susceptible of sale or utilization by the lessee, except that as to any byproduct which is a mineral named in section 1 of the Mineral Leasing Act of February 25, 1920, as amended (30 U.S.C. 181), the rate of royalty for such mineral shall be the same as that provided in that Act and the maximum rate of royalty for such mineral shall not exceed the maximum royalty applicable under that Act;

41 Stat. 437.

Rent.

(c) payment in advance of an annual rental of not less than $1 per acre or fraction thereof for each year of the lease. If there is no well on the leased lands capable of producing geothermal resources in commercial quantities, the failure to pay rental on or before the anniversary date shall terminate the lease by operation of law: *Provided, however*, That whenever the Secretary discovers that the rental payment due under a lease is paid timely but the amount of the payment is deficient because of an error or other reason and the deficiency is nominal, as determined by the Secretary pursuant to regulations prescribed by him, he shall notify the lessee of the deficiency and such lease shall not automatically terminate unless

the lessee fails to pay the deficiency within the period prescribed in the notice: *Provided further*, That, where any lease has been terminated automatically by operation of law under this section for failure to pay rental timely and it is shown to the satisfaction of the Secretary of the Interior that the failure to pay timely the lease rental was justifiable or not due to a lack of reasonable diligence, he in his judgment may reinstate the lease if—

(1) a petition for reinstatement, together with the required rental, is filed with the Secretary of the Interior; and

(2) no valid lease has been issued affecting any of the lands in the terminated lease prior to the filing of the petition for reinstatement; and

(d) a minimum royalty of $2 per acre or fraction thereof in lieu of rental payable at the expiration of each lease year for each producing lease, commencing with the lease year beginning on or after the commencement of production in commercial quantities. For the purpose of determining royalties hereunder the value of any geothermal steam and byproduct used by the lessee and not sold and reasonably susceptible of sale shall be determined by the Secretary, who shall take into consideration the cost of exploration and production and the economic value of the resource in terms of its ultimate utilization.

SEC. 6. (a) Geothermal leases shall be for a primary term of ten years. If geothermal steam is produced or utilized in commercial quantities within this term, such lease shall continue for so long thereafter as geothermal steam is produced or utilized in commercial quantities, but such continuation shall not exceed an additional forty years. Term. Limitation.

(b) If, at the end of such forty years, steam is produced or utilized in commercial quantities and the lands are not needed for other purposes, the lessee shall have a preferential right to a renewal of such lease for a second forty-year term in accordance with such terms and conditions as the Secretary deems appropriate. Renewal.

(c) Any lease for land on which, or for which under an approved cooperative or unit plan of development or operation, actual drilling operations were commenced prior to the end of its primary term and are being diligently prosecuted at that time shall be extended for five years and so long thereafter, but not more than thirty-five years, as geothermal steam is produced or utilized in commercial quantities. If, at the end of such extended term, steam is being produced or utilized in commercial quantities and the lands are not needed for other purposes, the lessee shall have a preferential right to a renewal of such lease for a second term in accordance with such terms and conditions as the Secretary deems appropriate. Extension.

(d) For purposes of subsection (a) of this section, production or utilization of geothermal steam in commercial quantities shall be deemed to include the completion of one or more wells producing or capable of producing geothermal steam in commercial quantities and a bona fide sale of such geothermal steam for delivery to or utilization by a facility or facilities not yet installed but scheduled for installation not later than fifteen years from the date of commencement of the primary term of the lease.

(e) Leases which have extended by reasons of production, or which have produced geothermal steam, and have been determined by the Secretary to be incapable of further commercial production and utilization of geothermal steam may be further extended for a period of not more than five years from the date of such determination but only for so long as one or more valuable byproducts are produced in commercial quantities. If such byproducts are leasable under the Mineral Leasing Act of February 25, 1920, as amended (30 U.S.C. 181, et seq.), or under the Mineral Leasing Act for Acquired Lands (30 U.S.C. 41 Stat. 437.

61 Stat. 913.

351-358), and the leasehold is primarily valuable for the production thereof, the lessee shall be entitled to convert his geothermal lease to a mineral lease under, and subject to all the terms and conditions of, such appropriate Act upon application at any time before expiration of the lease extension by reason of byproduct production. The lessee shall be entitled to locate under the mining laws all minerals which are not leasable and which would constitute a byproduct if commercial production or utilization of geothermal steam continued. The lessee in order to acquire the rights herein granted him shall complete the location of mineral claims within ninety days after the termination of the lease for geothermal steam. Any such converted lease or the surface of any mining claim located for geothermal byproducts mineral affecting lands withdrawn or acquired in aid of a function of a Federal department or agency, including the Department of the Interior, shall be subject to such additional terms and conditions as may be prescribed by such department or agency with respect to the additional operations or effects resulting from such conversion upon adequate utilization of the lands for the purpose for which they are administered.

(f) Minerals locatable under the mining laws of the United States in lands subject to a geothermal lease issued under the provisions of this Act which are not associated with the geothermal steam and associated geothermal resources of such lands as defined in section 2(c) herein shall be locatable under said mining laws in accordance with the principles of the Multiple Mineral Development Act (68 Stat. 708; found in 30 U.S.C. 521 et seq.).

Leases, acreage.

Limitation.

SEC. 7. A geothermal lease shall embrace a reasonably compact area of not more than two thousand five hundred and sixty acres, except where a departure therefrom is occasioned by an irregular subdivision or subdivisions. No person, association, or corporation, except as otherwise provided in this Act, shall take, hold, own, or control at one time, whether acquired directly from the Secretary under this Act or otherwise, any direct or indirect interest in Federal geothermal leases in any one State exceeding twenty thousand four hundred and eighty acres, including leases acquired under the provisions of section 4 of this Act.

Increase.

At any time after fifteen years from the effective date of this Act the Secretary, after public hearings, may increase this maximum holding in any one State by regulation, not to exceed fifty-one thousand two hundred acres.

Readjustment.

Notice.

SEC. 8. (a) The Secretary may readjust the terms and conditions, except as otherwise provided herein, of any geothermal lease issued under this Act at not less than ten-year intervals beginning ten years after the date the geothermal steam is produced, as determined by the Secretary. Each geothermal lease issued under this Act shall provide for such readjustment. The Secretary shall give notice of any proposed readjustment of terms and conditions, and, unless the lessee files with the Secretary objection to the proposed terms or relinquishes the lease within thirty days after receipt of such notice, the lessee shall conclusively be deemed to have agreed with such terms and conditions. If the lessee files objections, and no agreement can be reached between the Secretary and the lessee within a period of not less than sixty days, the lease may be terminated by either party.

(b) The Secretary may readjust the rentals and royalties of any geothermal lease issued under this Act at not less than twenty-year intervals beginning thirty-five years after the date geothermal steam is produced, as determined by the Secretary. In the event of any such readjustment neither the rental nor royalty may be increased by more than 50 per centum over the rental or royalty paid during the preceding period, and in no event shall the royalty payable exceed 22½ per centum. Each geothermal lease issue under this Act shall provide

for such readjustment. The Secretary shall give notice of any proposed readjustment of rentals and royalties, and, unless the lessee files with the Secretary objection to the proposed rentals and royalties or relinquishes the lease within thirty days after receipt of such notice, the lessee shall conclusively be deemed to have agreed with such terms and conditions. If the lessee files objections, and no agreement can be reached between the Secretary and the lessee within a period of not less than sixty days, the lease may be terminated by either party. Notice.

(c) Any readjustment of the terms and conditions as to use, protection, or restoration of the surface of any lease of lands withdrawn or acquired in aid of a function of a Federal department or agency other than the Department of the Interior may be made only upon notice to, and with the approval of, such department or agency.

Byproducts.

SEC. 9. If the production, use, or conversion of geothermal steam is susceptible of producing a valuable byproduct or byproducts, including commercially demineralized water for beneficial uses in accordance with applicable State water laws, the Secretary shall require substantial beneficial production or use thereof unless, in individual circumstances he modifies or waives this requirement in the interest of conservation of natural resources or for other reasons satisfactory to him. However, the production or use of such byproducts shall be subject to the rights of the holders of preexisting leases, claims, or permits covering the same land or the same minerals, if any.

Relinquishment.

SEC. 10. The holder of any geothermal lease at any time may make and file in the appropriate land office a written relinquishment of all rights under such lease or of any legal subdivision of the area covered by such lease. Such relinquishment shall be effective as of the date of its filing. Thereupon the lessee shall be released of all obligations thereafter accruing under said lease with respect to the lands relinquished, but no such relinquishment shall release such lessee, or his surety or bond, from any liability for breach of any obligation of the lease, other than an obligation to drill, accrued at the date of the relinquishment, or from the continued obligation, in accordance with the applicable lease terms and regulations, (1) to make payment of all accrued rentals and royalties, (2) to place all wells on the relinquished lands in condition for suspension or abandonment, and (3) to protect or restore substantially the surface and surface resources.

Suspension.

SEC. 11. The Secretary, upon application by the lessee, may authorize the lessee to suspend operations and production on a producing lease and he may, on his own motion, in the interest of conservation suspend operations on any lease but in either case he may extend the lease term for the period of any suspension, and he may waive, suspend, or reduce the rental or royalty required in such lease.

Leases, termination. Notice.

SEC. 12. Leases may be terminated by the Secretary for any violation of the regulations or lease terms after thirty days notice provided that such violation is not corrected within the notice period, or in the event the violation is such that it cannot be corrected within the notice period then provided that lessee has not commenced in good faith within said notice period to correct such violation and thereafter to proceed diligently to correct such violation. Lessee shall be entitled to a hearing on the matter of such claimed violation or proposed termination of lease if request for a hearing is made to the Secretary within the thirty-day period after notice. The period for correction of violation or commencement to correct such violation of regulations or of lease terms, as aforesaid, shall be extended to thirty days after the Secretary's decision after such hearing if the Secretary shall find that a violation exists.

SEC. 13. The Secretary may waive, suspend, or reduce the rental or royalty for any lease or portion thereof in the interests of conservation and to encourage the greatest ultimate recovery of geothermal

resources, if he determines that this is necessary to promote development or that the lease cannot be successfully operated under the lease terms.

Surface land, use.

SEC. 14. Subject to the other provisions of this Act, a lessee shall be entitled to use so much of the surface of the land covered by his geothermal lease as may be found by the Secretary to be necessary for the production, utilization, and conservation of geothermal resources.

SEC. 15. (a) Geothermal leases for lands withdrawn or acquired in aid of functions of the Department of the Interior may be issued only under such terms and conditions as the Secretary may prescribe to insure adequate utilization of the lands for the purposes for which they were withdrawn or acquired.

(b) Geothermal leases for lands withdrawn or acquired in aid of functions of the Department of Agriculture may be issued only with the consent of, and subject to such terms and conditions as may be prescribed by, the head of that Department to insure adequate utilization of the lands for the purposes for which they were withdrawn or acquired. Geothermal leases for lands to which section 24 of the Federal Power Act, as amended (16 U.S.C. 818), is applicable, may be issued only with the consent of, and subject to, such terms and conditions as the Federal Power Commission may prescribe to insure adequate utilization of such lands for power and related purposes.

41 Stat. 1075; 62 Stat. 275.

(c) Geothermal leases under this Act shall not be issued for lands administered in accordance with (1) the Act of August 25, 1916 (39 Stat. 535), as amended or supplemented, (2) for lands within a national recreation area, (3) for lands in a fish hatchery administered by the Secretary, wildlife refuge, wildlife range, game range, wildlife management area, waterfowl production area, or for lands acquired or reserved for the protection and conservation of fish and wildlife that are threatened with extinction, (4) for tribally or individually owned Indian trust or restricted lands, within or without the boundaries of Indian reservations.

16 USC 1.

Lessees, citizenship requirement.

SEC. 16. Leases under this Act may be issued only to citizens of the United States, associations of such citizens, corporations organized under the laws of the United States or of any State or the District of Columbia, or governmental units, including, without limitation, municipalities.

SEC. 17. Administration of this Act shall be under the principles of multiple use of lands and resources, and geothermal leases shall, insofar as feasible, allow for coexistence of other leases of the same lands for deposits of minerals under the laws applicable to them, for the location and production of claims under the mining laws, and for other uses of the areas covered by them. Operations under such other leases or for such other uses, however, shall not unreasonably interfere with or endanger operations under any lease issued pursuant to this Act, nor shall operations under leases so issued unreasonably interfere with or endanger operations under any lease, license, claim, or permit issued pursuant to the provisions of any other Act.

Cooperative or unit plan.

SEC. 18. For the purpose of properly conserving the natural resources of any geothermal pool, field, or like area, or any part thereof, lessees thereof and their representatives may unite with each other, or jointly or separately with others, in collectively adopting and operating under a cooperative or unit plan of development or operation of such pool, field, or like area, or any part thereof, whenever this is determined and certified by the Secretary to be necessary or advisable in the public interest. The Secretary may in his discretion and with the consent of the holders of leases involved, establish, alter, change, revoke, and make such regulations with reference to such leases in connection with the institution and operation of any such cooperative or unit plan as he may deem necessary or proper to secure reasonable protection of the

public interest. He may include in geothermal leases a provision requiring the lessee to operate under such a reasonable cooperative or unit plan, and he may prescribe such a plan under which such lessee shall operate, which shall adequately protect the rights of all parties in interest, including the United States. Any such plan may, in the discretion of the Secretary, provide for vesting in the Secretary or any other person, committee, or Federal or State agency designated therein, authority to alter or modify from time to time the rate of prospecting and development and the quantity and rate of production under such plan. All leases operated under any such plan approved or prescribed by the Secretary shall be excepted in determining holdings or control for the purposes of section 7 of this Act.

When separate tracts cannot be independently developed and operated in conformity with an established well-spacing or development program, any lease, or a portion thereof, may be pooled with other lands, whether or not owned by the United States, under a communitization or drilling agreement providing for an apportionment of production or royalties among the separate tracts of land comprising the drilling or spacing unit when determined by the Secretary to be in the public interest, and operations or production pursuant to such an agreement shall be deemed to be operations or production as to each lease committed thereto.

The Secretary is hereby authorized, on such conditions as he may prescribe, to approve operating, drilling, or development contracts made by one or more lessees of geothermal leases, with one or more persons, associations, or corporations whenever, in his discretion, the conservation of natural products or the public convenience or necessity may require or the interests of the United States may be best served thereby. All leases operated under such approved operating, drilling, or development contracts, and interests thereunder, shall be excepted in determining holdings or control under section 7 of this Act.

SEC. 19. Upon request of the Secretary, other Federal departments and agencies shall furnish him with any relevant data then in their possession or knowledge concerning or having bearing upon fair and adequate charges to be made for geothermal steam produced or to be produced for conversion to electric power or other purposes. Data given to any department or agency as confidential under law shall not be furnished in any fashion which identifies or tends to identify the business entity whose activities are the subject of such data or the person or persons who furnished such information.

SEC. 20. All moneys received under this Act from public lands under the jurisdiction of the Secretary shall be disposed of in the same manner as moneys received from the sale of public lands. Moneys received under this Act from other lands shall be disposed of in the same manner as other receipts from such lands. Moneys.

SEC. 21. (a) Within one hundred and twenty days after the effective date of this Act, the Secretary shall cause to be published in the Federal Register a determination of all lands which were included within any known geothermal resources area on the effective date of the Act. He shall likewise publish in the Federal Register from time to time his determination of other known geothermal resources areas specifying in each case the date the lands were included in such area; and Publication in Federal Register.

(b) Geothermal resources in lands the surface of which has passed from Federal ownership but in which the minerals have been reserved to the United States shall not be developed or produced except under geothermal leases made pursuant to this Act. If the Secretary of the Interior finds that such development is imminent, or that production from a well heretofore drilled on such lands is imminent, he shall so report to the Attorney General, and the Attorney General is authorized

and directed to institute an appropriate proceeding in the United States district court of the district in which such lands are located, to quiet the title of the United States in such resources, and if the court determines that the reservation of minerals to the United States in the lands involved included the geothermal resources, to enjoin their production otherwise than under the terms of this Act: *Provided*, That upon an authoritative judicial determination that Federal mineral reservation does not include geothermal steam and associated geothermal resources the duties of the Secretary of the Interior to report and of the Attorney General to institute proceedings, as hereinbefore set forth, shall cease.

SEC. 22. Nothing in this Act shall constitute an express or implied claim or denial on the part of the Federal Government as to its exemption from State water laws.

Waste, prevention.

SEC. 23. (a) All leases under this Act shall be subject to the condition that the lessee will, in conducting his exploration, development, and producing operations, use all reasonable precautions to prevent waste of geothermal steam and associated geothermal resources developed in the lands leased.

(b) Rights to develop and utilize geothermal steam and associated geothermal resources underlying lands owned by the United States may be acquired solely in accordance with the provisions of this Act.

Rules and regulations.

SEC. 24. The Secretary shall prescribe such rules and regulations as he may deem appropriate to carry out the provisions of this Act. Such regulations may include, without limitation, provisions for (a) the prevention of waste, (b) development and conservation of geothermal and other natural resources, (c) the protection of the public interest, (d) assignment, segregation, extension of terms, relinquishment of leases, development contracts, unitization, pooling, and drilling agreements, (e) compensatory royalty agreements, suspension of operations or production, and suspension or reduction of rentals or royalties, (f) the filing of surety bonds to assure compliance with the terms of the lease and to protect surface use and resources, (g) use of the surface by a lessee of the lands embraced in his lease, (h) the maintenance by the lessee of an active development program, and (i) protection of water quality and other environmental qualities.

SEC. 25. As to any land subject to geothermal leasing under section 3 of this Act, all laws which either (a) provide for the disposal of land by patent or other form of conveyance or by grant or by operation of law subject to a reservation of any mineral or (b) prevent or restrict the disposal of such land because of the mineral character of the land, shall hereafter be deemed to embrace geothermal steam and associated geothermal resources as a substance which either must be reserved or must prevent or restrict the disposal of such land, as the case may be. This section shall not be construed to affect grants, patents, or other forms of conveyances made prior to the date of enactment of this Act.

SEC. 26. The first two clauses in section 11 of the Act of August 13,
30 USC 530. 1954 (68 Stat. 708, 716), are amended to read as follows:

"As used in this Act, 'mineral leasing laws' shall mean the Act of
30 USC 181. February 25, 1920 (41 Stat. 437); the Act of April 17, 1926 (44 Stat.
30 USC 281. 301); the Act of February 7, 1927 (44 Stat. 1057); Geothermal Steam Act of 1970, and all Acts heretofore or hereafter enacted which are amendatory of or supplementary to any of the foregoing Acts; 'Leasing Act minerals' shall mean all minerals which, upon the effective date of this Act, are provided in the mineral leasing laws to be disposed of thereunder and all geothermal steam and associated geothermal resources which, upon the effective date of the Geothermal Steam Act of 1970, are provided in that Act to be disposed of thereunder;".

SEC. 27. The United States reserves the ownership of and the right to extract under such rules and regulations as the Secretary may prescribe oil, hydrocarbon gas, and helium from all geothermal steam and associated geothermal resources produced from lands leased under this Act in accordance with presently applicable laws: *Provided*, That whenever the right to extract oil, hydrocarbon gas, and helium from geothermal steam and associated geothermal resources produced from such lands is exercised pursuant to this section, it shall be exercised so as to cause no substantial interference with the production of geothermal steam and associated geothermal resources from such lands.

Certain mineral rights, retention by U. S.

Approved December 24, 1970.

LEGISLATIVE HISTORY:

HOUSE REPORT No. 91-1544 (Comm. on Interior and Insular Affairs).
SENATE REPORT No. 91-1160 (Comm. on Interior and Insular Affairs).
CONGRESSIONAL RECORD, Vol. 116 (1970):
Sept. 16, Oct. 14, Dec. 4, 10, considered and passed Senate.
Oct. 5, Dec. 9, considered and passed House.

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PART II

DEPARTMENT OF THE INTERIOR

Bureau of Land Management and Geological Survey

■

GEOTHERMAL RESOURCES

Leasing on Public, Acquired and Withdrawn Lands; Revision of Proposed Rule

DEPARTMENT OF THE INTERIOR

Bureau of Land Management

[43 CFR Parts 3000, 3200]

GEOTHERMAL RESOURCES

Leasing on Public, Acquired and Withdrawn Lands; Revision of Proposed Rule

The purpose of the revision in the proposed rule making for implementing the Geothermal Steam Act of December 24, 1970 (30 U.S.C. 1001–1025), is to provide the public with the revisions to the leasing regulations planned as a result of the public hearings and comments received on the Draft Environmental Statement and previously published proposed rules (36 FR 13722 and 37 FR 25282). The Act provides for the leasing of public lands for the purpose of geothermal resource exploration, development and production. The changes in these regulations, since the last publication on November 29, 1972, are primarily administrative and procedural in nature and the environmental impact of these regulations is not believed to be significantly different from the impact of the regulations previously published.

It is the policy of the Department of the Interior, whenever practicable, to afford the public an opportunity to participate in the rule making process. Accordingly, interested parties may submit written comments, suggestions, or objections with respect to the proposed regulations to the Geothermal Coordinator, Department of the Interior, Washington, DC 20240, on or before August 22, 1973.

A Final Environmental Statement will be issued in accordance with the provisions of section 102(2)(C) of the National Environmental Policy Act of 1969 (42 U.S.C. 4332(2)(C)) prior to promulgation of any leasing regulations.

1. Section 3000.0–5 of Subpart 3000, Chapter II, Title 43 of the Code of Federal Regulations is revised to read as follows:

§ 3000.0–5 Definitions.

As used in this subchapter:

(a) "Leasable minerals" means oil and gas. (1) Gas means any fluid, either combustible or noncombustible, which is produced in a natural state from the earth and which maintains a gaseous or rarefied state at ordinary temperature and pressure conditions. (2) Oil or crude oil means any liquid hydrocarbon substance which occurs naturally in the earth, including drip gasoline or other natural condensates recovered from gas, without resort to manufacturing process.

(b) "Other leasable minerals" means (1) Coal, chlorides, sulphates, carbonates, borates, silicates, or nitrates of potassium and sodium; sulphur in the States of Louisiana and New Mexico; phosphate; and native asphalt, solid and semisolid bitumen and bituminous rock (including oil impregnated rock or sands from which oil is recoverable only by special treatment after the deposit is mined or quarried). (2) Solid (hardrock) minerals; minerals in acquired lands which would be subject to location under the U.S. mining laws if located in the public domain lands.

(c) "Secretary" means the Secretary of the Interior or any person duly authorized to exercise the powers vested in that officer.

(d) "Director" means the Director of the Bureau of Land Management or any person duly authorized to exercise the powers vested in that officer.

(e) "State Director" means the Director of a Bureau of Land Management State office.

(f) "Authorized officer" means any person authorized by law or by lawful delegation of authority in the Bureau of Land Management to perform the duties described.

(g) "Proper BLM office" means the Bureau of Land Management office having jurisdiction over the leased lands or lands subject to lease.

(h) "Commercial quantities" means quantities sufficient to provide a return after all variable costs of production have been met.

(i) "Public domain lands" means original public domain lands which have never left Federal ownership; also, lands in Federal ownership which were obtained by the Government in exchange for public lands or for timber on such lands; also original public domain lands which have reverted to Federal ownership through operation of the public land laws.

(j) "Acquired lands" means lands which the United States obtains by deed through purchase or gift, or through condemnation proceedings. They are distinguished from public domain lands in that acquired lands may or may not have been originally owned by the Government. If originally owned by the Government such lands have been disposed of (patented) under the public land laws and thereafter reacquired by the United States.

(k) "Other lands" (1) "Withdrawn lands." Lands which have been withdrawn and dedicated to public purposes. (2) "Reserved lands." Lands which have been withdrawn from disposal and dedicated to a specific public purpose. (3) "Segregated lands." Lands included in a withdrawal, or in an application or entry or in a proper classification which segregates them from operation of the public land laws.

2. Section 3000.4 of Subpart 3000, Chapter II, Title 43 of the Code of Federal Regulations is revised to read as follows:

§ 3000.4 Appeals.

Any party to a case who is adversely affected by any official action or decision of an officer of the Bureau of Land Management or of an Administrative Law Judge, except a decision which has been approved by the Secretary, shall have a right of appeal to the Board of Land Appeals in the Office of Hearings and Appeals, Office of the Secretary. All appeals shall be governed by the rules of practice in Subpart E of Part 4 of this title. Nothing in this group shall be construed to prevent any interested party from seeking judicial review as authorized by law.

3. A new Group 3200 is added to Chapter II, Title 43 of the Code of Federal Regulations to read as follows:

Group 3200—Geothermal Resources Leasing

PART 3200—GEOTHERMAL RESOURCES LEASING; GENERAL

Subpart 3200—Geothermal Resources Leasing; General

§ 3200.0-3 Authority.

These regulations are issued pursuant to the Geothermal Steam Act of 1970 (84 Stat. 1566; 30 U.S.C. 1001-1025) and rights to develop and utilize geothermal resources in land subject to these regulations may be acquired only in accordance with these regulations.

§ 3200.0-5 Definitions.

As used in Group 3200, the term:

(a) "The Act" means the Geothermal Steam Act of 1970.

(b) "Geothermal lease" means a lease issued under authority of the Act; and unless the context indicates otherwise, "lease" means a "geothermal lease".

(c) "Geothermal resources" means geothermal steam and associated geothermal resources which include: (1) All products of geothermal processes, embracing indigenous steam, hot water and hot brines; (2) steam and other gases, hot water and hot brines resulting from water, gas, or other fluids artificially introduced into geothermal formations; (3) heat or other associated energy found in geothermal formations; and (4) any byproducts derived from them.

(d) "Byproduct" means (1) any mineral or minerals (exclusive of oil, hydrocarbon gas, and helium) which are found in solution or in association with geothermal steam and which have a value of less than 75 per centum of the value of the geothermal steam or are not, because of quantity, quality, or technical difficulties in extraction and production, of sufficient value to warrant extraction and production by themselves, and (2) commercially demineralized water.

(e) "Sole party in interest" means a party who is and will be vested with all legal and equitable rights under the lease. No one is, or shall be deemed to be, a sole party in interest with respect to a lease in which any other party has any interest in the lease.

(f) "Interest in the lease" means any interest whatever in a geothermal lease, including, but not limited to: A record title interest; a working interest; an operating right; an overriding royalty interest; a claim to any prospective or future advantage or benefit from a lease; a participation in any increment, issue, or profit which may be derived, or accrue in any manner, from the lease based upon, or pursuant to, any agreement or understanding in existence at the time when the offer is filed; and an agreement pertaining to any of the foregoing.

(g) "Supervisor" means a representative of the Secretary, subject to the direction and supervisory authority of the Director, the Chief, Conservation Division, Geological Survey and the appropriate Regional Conservation Manager, Conservation Division, Geological Survey, authorized and empowered to regulate operations and to perform other duties prescribed in the regulations in this part or any subordinate of such representative acting under his direction.

(h) "Primary term" means the first 10 years in the life of the lease, exclusive of any period of suspension of operations or production, or both.

(i) "Area of operation" means that area of the leased lands which is required for exploration, development and producing operations, and which is delineated on a map or plat which is made a part of the approved plan of operations. It encompasses the area generally needed for wells, flow lines, separators, surge tanks, drill pads, mud pits, workshops, and other such facilities used for on-project geothermal resources field exploration, development and production operations.

(j) "Geothermal resource province" means an area in which higher than normal temperatures are likely to occur with depth and there is a reasonable possibility of finding reservoir rocks that will yield steam or heated fluids to wells. The classification of such a province is based on geologic inference and a determination that the area possesses one or more of the following characteristics:

(1) Volcanism of late Tertiary or Quaternary age—especially caldera structures, cones, and volcanic vents; (2) geysers, fumaroles, mud volcanoes, or thermal springs at least 40° F. higher than average ambient temperature; and (3) subsurface geothermal gradients generally in excess of two times normal, as reflected in deep water wells, oil well tests, and other test holes.

(k) "Known geothermal resource area" or "KGRA" means an area in which the geology, nearby discoveries, competitive interests, or other indicia would, in the opinion of the Secretary, engender a belief in men who are experienced in the subject matter that the prospects for extraction of geothermal steam or associated geothermal resources are good enough to warrant expenditures of money for that purpose.

(l) In determining whether the geology of an area is of such a nature that the area should be designated a KGRA the Director, Geological Survey, acting for the Secretary, shall use such geologic and technical evidence as he shall deem appropriate, including the following:

(i) The existence of siliceous sinter and natural geysers;

(ii) The temperatures of fumaroles, thermal springs, and mud volcanoes;

(iii) The SiO_2 content of spring water;

(iv) The Na/K ratio in spring waters of hot-water systems;

(v) The existence of volcanoes and calderas of late Teirtary or Quaternary age;

(vi) Conductive heat flows and geothermal gradient;

(vii) The porosity and the permeability of a potential reservoir;

(viii) The results of electrical resistivity surveys;

(ix) The results of magnetic, gravity, and airborne infrared geophysical surveys; and

(x) The information obtained through other geophysical methods such as microseismic, seismic ground noise, electromagnetic, and telluric surveys if such methods prove to have significant use in evaluation.

(2) For purposes of KGRA classification, a "discovery" or "discoveries" will be considered to be any well deemed by the Director, Geological Survey, to be capable of producing geothermal resources in commercial quantities and, where the geological structure is not known, "nearby" will be considered to be five miles or less from any such discovery. Lands nearby a discovery will be classified as KGRA unless the Geological Survey determines that the lands are on a different geologic structure from the discovery. Where the Geological Survey has determined the extent of a structure on which a discovery has been made, all land in that structural area contributing geothermal resources to that discovery will be deemed a KGRA regardless of the distance from the discovery.

(3) "Competitive interest" shall exist in the entire area covered by an appli-

cation for a geothermal lease if at least one-half of the lands covered by that application are also covered by another application which was filed during the same application filing period, whether or not that other application is subsequently withdrawn. Competitive interest shall not be deemed to exist in the entire area covered by an application because of an overlapping application, if less than one-half of the lands subject to the first application are covered by any other single application filed during the same application filing period; however, some of the lands subject to the first application may be determined to be KGRA pursuant to the first sentence of this subparagraph (3).

(l) "Primarily valuable" means the principal mineral value for which the leasehold is being produced.

§ 3200.0–6 Preleasing procedures.

(a) When an area is initially considered for geothermal leasing or when the need arises, the Director shall request other interested Bureaus and Federal agencies to prepare reports describing, to the extent known, resources contained within the general area and the potential effect of geothermal resources operations upon the resources of the area and its total environment.

(b) Prior to the final selection of tracts for leasing, the Director, or the head of the agency charged with the administration of the surface, when requested by the Director, shall evaluate fully the potential effect of the leasing program on the total environment, fish and other aquatic resources, wildlife habitat and populations, aesthetics, recreation, and other resources in the entire area during exploratory, developmental, and operational phases. This evaluation will consider the potential impact of the possible development and utilization of the geothermal resources including the construction of power generating plants and transmission facilities on lands which may or may not be included in a geothermal lease. To aid him in his evaluation and selection of tracts the Director may request and consider the views and recommendations of appropriate Federal agencies, may hold public hearings after appropriate notice, and may consult with State agencies, organizations, industries, and individuals, and shall consider all other potential uses of the land and its natural resources. If the Director determines that the issuance of leases in an area would be a major Federal action significantly affecting the quality of the human environment, he shall issue no leases in that area unless an environmental impact statement under section 102(2)(C) of the National Environmental Policy Act of 1969 (42 U.S.C. 4332(2)(C)) has been issued. The Director shall develop special terms and conditions to be included in leases when they are needed to protect the environment, to permit use of the land for other purposes, and to protect other natural resources. If tracts are offered for competitive leasing, any terms and conditions to be included in leases for such tracts shall be published in the notice announcing the availability of the land for leasing.

§ 3200.0–7 Cross reference.

(a) The regulations governing operations under geothermal leases are found in 30 CFR Part 270

(b) The regulations setting forth the basic policies for management of the public lands are found in Part 1725 of this chapter.

§ 3200.0–8 Use of surface.

(a) A lessee shall be entitled to use for the production, utilization, and conservation of geothermal resources only so much of the surface of the leased Federal lands as is deemed necessary for such purposes. The lessee shall have the right to use so much of the leased lands as may be deemed necessary for a power generation plant or a commercial or industrial facility, and may apply for the right to use so much of other Federal lands as may be deemed necessary for such purposes; however, any use of the leased lands or other Federal lands for a power generation plant or a commercial or industrial facility will be authorized only under a separate permit issued by the appropriate agency for that specific use and subject to all terms and conditions which it may include in that permit. The uses of the lands within the area of operation are subject to the supervision of the supervisor, and the uses of the remaining leased lands or other Federal lands are subject to the supervision of the appropriate surface management agency. The lessee shall not be entitled to use any mineral materials subject to the Materials Act except as provided by Part 3600 of this chapter.

(b) Operations under other leases or uses on the same lands shall not unreasonably interfere with or endanger operations under leases issued under these regulations nor shall operations under these regulations unreasonably interfere with or endanger operations under any lease, license, claim, permit, or other authorized use pursuant to the provisions of any other Act.

Subpart 3201—Available Lands; Limitations, Unit Agreements

§ 3201.1 Lands subject to geothermal leasing.

§ 3201.1–1 General.

Subject to the exceptions listed below, geothermal leases may be issued in combination or separately for (a) lands administered by the Secretary of the Interior; (b) national forest lands or other lands administered by the Department of Agriculture through the Forest Service; and (c) geothermal resources in lands which have been conveyed by the United States subject to a reservation to the United States of geothermal resources.

§ 3201.1–2 Department of the Interior.

(a) Except as provided in this section, leases may be issued in accordance with the regulations in this part for withdrawn lands, for acquired lands, and for geothermal resources in lands which have passed from Federal ownership subject to a reservation to the United States of the geothermal resources therein where such lands or resources are administered by the Secretary of the Interior.

(b) Notwithstanding any other provision in these regulations, geothermal leases shall not be issued for: (1) Lands which the Secretary has identified or may identify as being necessary to the performance of his or any other Federal agency's authorized functions, and on which geothermal resource development would in his judgment interfere with such functions; or (2) lands respecting which the Secretary has made or may make a finding that the issuance of geothermal leases would be contrary to the public interest. Upon receipt of an application for a geothermal lease affecting lands withdrawn under section 3 of the Reclamation Act of 1902 (43 U.S.C. 416) or any other appropriate authority, notice thereof and an opportunity to comment thereon shall be given to the head of the agency for whose benefit the withdrawal was made. No geothermal lease affecting lands withdrawn for any agency outside the Department of the Interior shall be leased without the consent of the head of the agency for which the lands are withdrawn. Where leases are issued under Part 3210, 3211, or 3220 for lands neighboring such reserved lands, the lessees shall be required to perform such lease operations and take such measures as are prescribed by the Secretary for the protection of the Federal interests therein.

§ 3201.1–3 Department of Agriculture.

Leases for lands withdrawn or acquired in aid of functions of the Department of Agriculture, for example, lands administered by the Forest Service, may be issued by the Secretary of the Interior only with the consent of, and subject to such terms and conditions as may be prescribed by, the head of that Department to insure adequate utilization of the lands for the purpose for which they were withdrawn or acquired.

§ 3201.1–4 Federal Power Commission.

Leases for lands to which section 24 of the Federal Power Act, as amended (16 U.S.C. 818), is applicable, may be issued by the Secretary of the Interior only with the consent of, and subject to, such terms and conditions as the Federal Power Commission may prescribe to insure adequate utilization of such lands for power and related purposes.

§ 3201.1–5 Patented lands.

(a) Geothermal resources in lands which have passed from Federal ownership subject to a reservation to the United States of geothermal resources therein may be leased under the regulations in this group subject to the provisions in this part and to such terms and conditions as may be prescribed by the authorized officer to insure adequate protection of the patented lands and any improvements thereon.

(b) Geothermal resources in lands the surface of which has passed from Federal ownership but in which the minerals have been reserved to the United States shall not be developed or produced except under terms and conditions prescribed by the Secretary and pursuant to any agreements made therefor while the question of the title to such resources is being resolved pursuant to the provisions of section 21(b) of the Act.

§ 3201.1–6 **Excepted areas.**

Leases shall not be issued for lands which are: (a) Administered under the National Park System; (b) within a national recreation area; (c) in a fish hatchery administered by the Secretary, wildlife refuge, wildlife range, game range, wildlife management area, or waterfowl production area, or for lands acquired or reserved for the protection and conservation of fish and wildlife which are threatened with extinction; or (d) tribally or individually owned Indian trust or restricted lands, within or without the boundaries of Indian reservations.

§ 3201.2 **Acreage limitations.**

(a) *Maximum holdings.* No citizen, association, corporation, or governmental unit shall take, hold, own, or control at one time, whether acquired directly from the Secretary or otherwise, any direct or indirect interest in Federal leases and in applications for Federal leases in any one State exceeding 20,480 acres. Nor may any citizen, association, or corporation be permitted to convert mineral leases, permits, applications therefor, or mining claims, pursuant to the provisions of section 4 (a)-(f) of the Act into geothermal leases for more than 10,240 acres. No citizen, association, corporation, or governmental unit shall be charged with the acreage embraced in an application for a lease until that application has been given priority over all other applications for lease for all or some of the land embraced in that application.

(b) *Computation.* In computing acreage holdings or control, the accountable acreage of a party owning an undivided interest in a lease shall be that party's proportionate part of the total lease acreage. Likewise, the accountable acreage of a party owning an interest in a corporation or association shall be his proportionate part of the corporation's or association's accountable acreage except that no person shall be charged with his pro rata share of any acreage holdings of any association or corporation unless he is the beneficial owner of more than 20 per centum of the stock or other instruments of ownership or control of that association or corporation. Parties owning a royalty or other interest determined by or payable out of a percentage of production from a lease will be charged with a similar percentage of the total lease acreage.

(1) An association shall not be deemed to exist between the parties to a contract for development of leased lands, whether or not coupled with an interest in the lease, nor between colessees, but each party to any such contract or each colessee will be charged with his proportionate interest in the lease. No holding of acreage in common by the same persons in excess of the maximum acreage specified in the law for any one lessee will be permitted.

(2) Lessees holding acreage in common shall be considered a single entity and cannot hold acreage in excess of the maximum specified in the law for any one lessee.

(c) *Excepted acreage.* Leases or applications for leases committed to any unit or cooperative plan approved or prescribed by the Secretary of the Interior shall not be included in computing accountable acreage. Leases or applications for leases subject to an operating, drilling or development contract approved by the Secretary of the Interior pursuant to section 18 of the act, other than communization agreements, shall be excepted in determining the accountable acreage of the lessees or operators.

(d) *Excess acreage.* (1) Where, as the result of the termination of contraction of a unit or cooperative plan, or the elimination of a lease from operating, drilling, or development plan, a party holds or controls excess accountable acreage, such party shall have 90 days from such termination or contraction or elimination in which to reduce his holdings to the prescribed limitation and to file proof of such reduction in the proper BLM office.

(2) If any person holding or controlling only leases or interests in leases if found to hold accountable acreage in violation of the provisions of this section and of the act, the last lease or leases or interest or interests acquired by him which created the excess acreage holdings shall be canceled or forfeited in their entirety, even though only part of the acreage in the lease or interest constitutes excess holdings, unless it can be shown to the satisfaction of the Director of the Bureau of Land Management that the holding or control of the excess acreage is not the result of negligence or willful intent in which event the lease or leases shall be canceled only to the extent of the excess acreage.

(3) Any person holding or controlling leases or interests in leases only, or applications for leases only, or both leases or interests in leases and applications for leases below the acreage limitation provided in this section, shall be subject to these rules:

(i) If he files an application which causes him to exceed the acreage limitation, that application will be rejected. (ii) For tracts not subject to the simultaneous filing procedures of subpart 3211, if he files a group of applications at the same time, any one of which causes him to exceed the acreage limitations, the entire group of applications will be rejected. (iii) If he files an applicatiön in the drawing procedures under subpart 3211, he shall be charged with the acreage thereof only if his application is the only application filed or his application is successfully drawn so that his application has first priority. If that application causes him to exceed the acreage limitation, the application will be rejected. If he files at the same time a group of applications for tracts subject to the drawing procedures under subpart 3211, any offer which is successfully drawn after he reaches the acreage limitation shall be rejected.

(4) If any person holding or controlling both leases or interests in leases and applications for leases, or only applications for leases below the acreage limitation provided in this section, acquires a lease or leases, or an interest or interests therein, which cause him to exceed the acreage limitation, his most recently filed application for lease or applications for leases then containing acreage in excess of the limitation provided in this section will be rejected in its or their entirety. For the purpose of this subparagraph, time of filing shall be determined by the time of filing marked on the application, or, if the same time is marked on two or more applications, by the serial number of the applications.

(5) The provisions of this paragraph shall not limit any action which the Department may take with respect to excess acreage holdings in cases not otherwise covered by this paragraph.

(e) *Showing required.* No lease will be issued and no transfer or operating agreement will be approved until it has been shown that the applicant, operator, or transferee is entitled to hold the acreage or obtain the operating rights. At any time upon request by the authorized officer, the record title holder of any lease or a lease operator or a lease applicant may be required to file in the proper BLM office a statement, showing as of a specified date the serial number and the date of each lease of which he is the record holder, or under which he holds operating rights, and each application for lease held or filed by him in the particular State setting forth the acreage covered thereby, and the nature, extent and acreage interest, including royalty interests held by him in any geothermal lease of which the reporting party is not the lessee of record, whether by corporate stock ownership, interest in unincorporated associations and partnerships, or in any other manner.

§ 3201.3 **Leases within unit areas.**

Before issuance of a geothermal lease for lands within an approved unit agreement, the lease applicant or successful bidder will be required to file evidence that he has entered into an agreement with the unit operator for the development and operation of the lands in a lease if issued to him under and pursuant to the terms and provisions of the approved unit agreement, or a statement giving satisfactory reasons for the failure to enter into such agreement. If such statement is acceptable, he will be permitted to operate independently but will be required to perform his operations in a manner which the Supervisor deems to be consistent with the unit operations.

Subpart 3202—Qualifications of Lessees

§ 3202.1 Who may hold leases.

Leases may be issued only to: (a) Citizens of the United States who have reached the age of majority; (b) associations of such citizens; (c) corporations organized under the laws of the United States, any state or the District of Columbia; or (d) governmental units, including, without limitation, municipalities. The term "association" includes a partnership.

§ 3202.2 Statements required to be submitted.

§ 3202.2–1 General.

(a) Each applicant for a lease is required to submit with his application a statement that his interests, direct and indirect, in Federal geothermal leases and applications, do not exceed the acreage limitations prescribed in § 3201.2, together with a statement of his citizenship.

(b) If the applicant is an association or corporation the application must be accompanied by: (1) A statement showing that it is authorized to hold geothermal leases; (2) a statement that the officer executing the application is authorized to act on behalf of the association or corporation; (3) a statement setting forth the State in which it was incorporated or formed and the names and addresses of all members or stockholders holding more than 20 percent of the association or corporation; and (4) a statement from each person owning or controlling more than 20 percent of the association or corporation setting forth his citizenship and his holdings.

(c) If the applicant is a municipality, or governmental unit, the application must be accompanied by: (1) A statement showing that it is authorized to hold geothermal leases; (2) a statement that the officer executing the application is authorized to act on behalf of the municipality or governmental unit, and (3) a copy of its governing body's resolution authorizing such action.

§ 3202.2–2 Guardian or trustee.

(a) *Guardian*. If the application is made by a guardian, he must submit: (1) A certified copy of the court order authorizing him to act as guardian and, in behalf of his ward, to enter into contractual agreements and to fulfill all obligations arising under the lease; and (2) statements as to the citizenship and holdings under the Act of himself and of each person under his guardianship for whom the application is made.

(b) *Trustee*. If the application is made by a trustee, he must submit a copy of the instrument establishing the trust or a certified copy of the court order authorizing him to act as trustee, in behalf of the beneficiary, as to all obligations arising under the lease; and statements as to the citizenship and holdings under the Act of himself and of each beneficiary.

§ 3202.2–3 Attorney-in-fact.

If an application is filed by an attorney-in-fact, it must be accompanied by a statement as to his authority to act.

§ 3202.2–4 Statements previously filed.

Where the statements required by § 3202.2 have been previously filed a reference by serial number to the record in which they have been filed, together with a statement as to any amendments will be accepted.

§ 3202.2–5 Showing as to sole party in interest.

Each application must be accompanied either by a signed statement by the applicant that he is the sole party in interest, or by a signed statement by the applicant setting forth the names of all other persons who have an interest in the lease and their qualifications to hold a lease. Where the applicant is not the sole party in interest, separate statements must be signed by each of the parties and by the applicant setting forth the nature of the agreement between them. All interested parties must furnish evidence of their qualifications to hold such lease interest. These separate statements must be filed in the proper BLM office not later than 15 days after the filing of the application.

§ 3202.2–6 Heirs and devisees (estates).

If an applicant or a successful bidder dies before the lease is issued, the lease will be issued to the executor or administrator of the estate if probate of the estate has not been completed, and if probate has been completed, or is not required, to the heirs or devisees, provided there is filed in all cases an application to lease in compliance with the requirements of this section which will be effective as of the effective date of the original application filed by the deceased. If there are any minor heirs or devisees, the application can only be made by their legal guardian or trustee in his name. Each such application must be accompanied by the following information:

(a) Where probate of the estate has not been completed:

(1) Evidence that the person who as executor or administrator submits the application, and bond form if a bond is required, has authority to act in that capacity and to sign the application and bond forms.

(2) A statement over the signature of each heir or devisee or, if the heir or devisee is a minor, over the signature of his legal guardian or trustee, concerning citizenship and holdings.

(3) Evidence that the heirs or devisees are the heirs or devisees of the deceased applicant or successful bidder and are the only heirs or devisees of the deceased.

(b) Where the executor or administrator has been discharged or no probate proceedings are required:

(1) A certified copy of the will or decree of distribution, if any, and if not, a statement signed by the heirs that they are the only heirs of the applicant or successful bidder and the provisions of the law of the deceased's last domicile showing that no probate is required.

(2) A statement over the signature of each of the heirs or devisees with reference to holdings and citizenship. If the heir or devisee is a minor, the statement must be over the signature of the guardian or trustee.

§ 3202.2–7 Fractional present interests.

(a) An application for a fractional present interest noncompetitive lease must be executed on a form approved by the Director and it must be accompanied by a statement showing the extent of the applicant's ownership of the operating rights to the fractional geothermal resources interest not owned by the United States in each tract covered by the application to lease. Ordinarily, the issuance of a lease to one who, upon such issuance, would own less than 50 percent of the operating rights in any such tract, will not be regarded as in the public interest, and an application leading to such results will be rejected.

(b) Geothermal resources in lands which have passed from Federal ownership but which lands have been purchased by the Federal Government with a fractional interest in the geothermal resources shall not be developed or produced, except under prescribed terms and conditions and pursuant to any agreement made between the parties of interest prior to the resolution of the question of ownership of the geothermal resources.

Subpart 3203—Leasing Terms

§ 3203.1 Primary and additional term.

§ 3203.1–1 Dating of leases.

All geothermal leases will be dated as of the first day of the month following the date on which the leases are signed on behalf of the lessor except that, where prior written request has been made, a lease may be dated as of the first day of the month within which it is so signed. A renewal lease will be dated from the termination of the original lease.

§ 3203.1–2 Primary term.

All leases shall be for a primary term of 10 years.

§ 3203.1–3 Additional term.

(a) If geothermal steam is produced or utilized in commercial quantities within the primary term of a lease, that lease shall continue for so long thereafter as geothermal steam is produced or utilized in commercial quantities, but the lease shall in no event continue for more than 40 years after the end of the primary term except that the lessee shall have a preferential right to a renewal of his lease for a second 40-year term upon such terms and conditions as the authorized officer deems appropriate, if at the end of the first 40-year term the lands are not needed for another pur-

pose and geothermal steam is produced or utilized in commercial quantities. Production or utilization of geothermal steam in commercial quantites shall be deemed to include the completion of one or more wells producing or capable of producing geothermal steam in commercial quantities and a bona fide sale of such geothermal steam for delivery to or utilization by a facility or facilities not yet installed but scheduled for installation not later than 15 years from the date of commencement of the primary term of the lease.

§ 3203.1–4 Extensions.

(a) A lease which has been extended by reason of production, or on which geothermal steam has been produced, and which has been determined by the Secretary to be incapable of further commercial production and utilization of geothermal steam may be further extended so long as one or more valuable byproducts are produced in commercial quantities but for not more than 5 years.

(b) Where the lessee commenced actual drilling operations prior to the end of the primary term and those operations are being diligently prosecuted at that time, a lease may also be extended for a period of five years and so long thereafter as geothermal steam is produced or utilized in commercial quantities (but for not more than 35 years).

(c) A lease committed to a cooperative plan, communitization agreement or a unit plan under or for which actual drilling operations were commenced prior to the end of the primary term of the lease, shall, if such operations are being diligently prosecuted at that time be extended for a period of five years and so long thereafter as geothermal steam is produced or utilized in commercial quantities (but for not more than thirty five years).

(d) Any lease on which there has been a suspension of operations or production, or both, under 30 CFR 270.17 shall continue in effect for the life of the suspension and, at the end of the suspension, shall be extended for a period equal to that portion of the primary term during which the suspension was in effect.

(e) If, at the end of 40 years after the conclusion of the primary term, steam is being produced or utilized in commercial quantities and the lands are not needed for other purposes, the lessee shall have a right to a renewal of the lease for a second 40-year term on such terms and conditions as the Secretary deems appropriate.

§ 3203.1–5 Segregation of leases on commitment to, or contraction of, cooperative or unit plan or cummunitization agreement.

(a) Any lease committed to any cooperative plan, cummunization agreement, or unit plan, which covers lands within and lands outside the area covered by the plan or agreement, shall be segregated, as of the effective date of that plan or agreement, into separate leases, one covering the lands committed to that plan or agreement and the other as to the lands not so committed. The segregated lease covering the portion of the lands not subject to that plan or agreement shall not be entitled to an extension by reason of the segregation, but the term of the lease of such segregated lands shall be as provided in the original lease.

(b) When only part of the land subject to a lease included in a cooperative plan, a communitization agreement, or a unit plan is excluded from that plan or agreement because of the contraction of the area subject to that plan or agreement, the part of the lease which is excluded and the part which remains subject to the plan or agreement shall be segregated into separate leases. The term of the segregated lease composed of the excluded land shall not be extended because of production in commercial quantities or the existence of a producible well on the segregated lease remaining subject to the cooperative or unit plan or the communitization agreement or because actual drilling operations were at the time of contraction being conducted on that other lease, but the term of the lease composed of the excluded land shall be as provided in the original lease.

§ 3203.1–6 Conversion to mineral leases or mining claims.

(a) If the byproducts capable of being produced in commercial quantities are leasable under the Mineral Leasing Act of February 25, 1920 as amended and supplemented (30 U.S.C. sections 181–287), or under the Mineral Leasing Act for Acquired Lands (30 U.S.C. sections 351–359), and the leasehold is primarily valuable for the production thereof, the lessee shall be intitled to convert his geothermal lease to a mineral lease under and subject to all the terms and conditions of the appropriate Act upon application at any time before expiration of the lease extension by reason of byproduct production.

(b) The lessee shall be entitled to locate under the mining laws all minerals which are not leasable and which would constitute a byproduct if commercial production or utilization of geothermal steam continued. The lessee, in order to acquire the rights herein granted him, shall complete the location of mineral claims within 90 days after the termination of the goethermal lease.

(c) Any lease converted under paragraph (a) of this section or under paragraph (b) of this section affecting lands withdrawn or acquired in aid of a function of a Federal department or agency, including the Department of the Interior, shall be subject to such additional terms and conditions as may be prescribed by that department or agency with respect to the additional operations or affects resulting from such conversion upon the utilization of the lands for the purpose for which they are administered.

§ 3203.2 Lease acreage limitation.

A geothermal lease may not embrace more than 2,560 acres in a reasonably compact area, except where a departure is occasioned by an irregular subdivision or subdivisions, entirely within an area of six miles square or within an area not exceeding six surveyed or protracted sections in length or width measured in cardinal directions. Where a departure is occasioned by an irregular subdivision, the leased acreage may exceed 2,560 acres by an amount which is smaller than the amount by which the area would be less than 2,560 acres if the irregular subdivision were excluded. No lease will be issued for less than 640 acres, except at the discretion of the Secretary, or where a departure is occasioned by an irregular subdivision, or as provided for in Subpart 3230 of this chapter. In event of a departure, the leased acreage may be less than 640 acres by amount which is smaller than the amount by which the area would be more than 640 acres if the irregular subdivision were added.

§ 3203.3 Consolidation of leases.

Two or more contiguous leases issued to the same lessee may be consolidated if the total combined acreage does not exceed 2,560 acres. Except where a deexceed 2,560 acres, except where a larger acreage is caused by an irregular subdivision or subdivisions as stated in § 3203.2.

§ 3203.4 Description of lands.

Applications and nominations shall include a description of the lands sought to be included in a geothermal lease. If the lands have been surveyed under the public land rectangular system, each application or nomination shall describe the lands by legal subdivision, section, township, and range. If the lands have not been so surveyed, each application shall describe the lands by metes and bounds, giving courses and distances between the successive angle points on the boundary of the tract, and connected by courses and distances to a monument or to a prominent topographic feature. When protracted surveys have been approved and the effective date thereof published in the FEDERAL REGISTER, each application or nomination for lands shown on such protracted surveys, filed on or after such effective date, shall describe the lands according to the legal subdivision, section, township, and range shown on the approved protracted surveys.

§ 3203.5 Diligent exploration.

Each geothermal lease will include provisions for the diligent exploration of the leased resources until there is production in commercial quantities applicable to the lands subject to the lease, and failure to perform such exploration may subject the lease to termination. Diligent exploration means exploration operations (subsequent to the issuance of the lease) on, or related to the leased lands, including, but not limited to, operations such as geochemical surveys, heat flow measurements, core drilling, or drilling of a test well. Exploration operations, in order to qualify as diligent exploration, must be approved by the Supervisor, and evidence of all expendi-

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tures therefor and the results thereof must be submitted annually to the Supervisor in compliance with applicable regulations and Geothermal Resources Operational Orders or upon his request. Moreover, after the fifth year of the primary lease term, exploration operations, in order to qualify as diligent exploration for a year, must entail expenditures during that year equal to at least two times the sum of (a) the minimum annual rental required by statute, and (b) the amount of rental for that year in excess of the fifth year's rental, but in no event shall the required expenditures exceed twice the rental for the 10th year. However, any expenditures for diligent operations during the first 5 years of the lease and any expenditures for diligent operations during any subsequent year in excess of the minimum required expenditures for that year may be credited, in such proportions as the lessee may designate, against (1) expenditures needed to qualify exploration operations as diligent operations for future years, or (2) any rental requirement for that or any future years in excess of the fifth year's rental pursuant to § 3205.3–3.

Subpart 3204—Surface Management Requirements, Special Requirements

§ 3204.1 General.

A lessee shall comply with and be bound by the following general terms and conditions, the specific requirements contained in the lease stipulations and any GRO orders that may be issued pursuant to 30 CFR 270.11. Assuring compliance with the requirements of this section is the responsibility of the Supervisor as to the lands within the area of operations and is the responsibility of the appropriate land management agency as to the remaining lands in the lease.

(a) *Equal employment opportunity.* The lessee shall comply with Executive Order 11246, as amended, 30 F.R. 12319 (1965), and regulations issued pursuant thereto, 41 CFR Chapter 60 and Part 17 of this chapter.

(b) *Public access.* (1) The lessee shall permit free and unrestricted public access to and upon the leased lands for all lawful and proper purposes except in areas where such access would unduly interfere with operations under the lease or would constitute a hazard to health and safety. Restrictions on access will not be allowed without prior approval.

(2) During construction, the lessee shall regulate public access and vehicular traffic to protect the public, wildlife, and livestock from hazards associated with the project. For this purpose, the lessee shall provide warnings, fencing, flag men, barricades, and other safety measures as appropriate.

(c) *Pollution abatement.* The lessee shall comply with all Federal and State standards with respect to the control of all forms of air, land, water, and noise pollution, including, but not limited to, the control of erosion and the disposal of liquid, solid, and gaseous wastes. The Supervisor may, in his discretion, establish additional and more stringent standards, and, if he does so, the lessee shall comply with those standards. The lessee, in addition to any other action required by those standards, shall take the following specific actions:

(1) *Pesticides and herbicides.* The lessee shall comply with all rules issued by the Department of the Interior and the Environmental Protection Agency pertaining to the use of poisonous substances on public lands.

(2) *Water pollution.* The lessee shall conduct lease operations and maintenance in a manner consistent with Federal and State water quality standards and public health and safety standards. Toxic materials shall not be released into any surface waters or underground waters. Reinjection of waste geothermal fluids into geothermal or other suitable aquifers may be permitted when approved by the Supervisor.

(3) *Air pollution.* The lessee shall control emissions from operations in accordance with Federal and State air quality standards.

(4) *Erosion control.* The lessee shall minimize disturbance to vegetation, drainage channels, and streambanks. The lessee shall employ such soil and resource conservation and protection measures on the leased lands as the Supervisor deems necessary.

(5) *Noise control.* The lessee shall control noise emissions from operations.

(d) *Sanitation and waste disposal.* The lessee shall remove or dispose of all waste generated in connection with the operation in a manner acceptable to the Supervisor. The term "waste" as used in this stipulation means all discarded matter, including but not limited to human waste, trash, garbage, refuse, petroleum products, and waste material resulting from the extraction and processing operation.

(e) *Land subsidence, seismic activity.* The lessee shall take precautions necessary to minimize land subsidence or seismic activity which could result from production of geothermal resources and the disposal of waste fluid where such activity could damage or curtail the use of the geothermal resources or other resources, or other uses of the land and take such measures as stipulated to: (1) monitor operations for land subsidence and for seismic activity; and (2) maintain, and when requested, make available to the lessor, records of all monitoring activities.

(f) *Aesthetics.* The lessee shall take aesthetics into account in the planning, design, and construction of facilities on the leased premises.

(g) *Fish and wildlife.* The lessee shall employ such measures as are deemed necessary to protect fish and wildlife and their habitat.

(h) *Antiquities and historical sites.* The lessee shall conduct activities on discovered, known or suspected archeological, paleontological, or historical sites in accordance with lease terms or specific instructions.

(i) *Restoration.* The lessee shall provide for the restoration of all disturbed lands in an approved manner.

(j) The lessee shall submit semi-annual reports to the authorized officer on compliance with the requirements of paragraphs (b)–(i) of this section and on any significant environmental damage suffered by the lands subject to his lease. However, if, after operations have begun, the lessee is required to submit a similar report under 30 CFR 270.76, he may fulfill the requirement of this subsection by submitting to the authorized officer a copy of that report.

§ 3204.2 Waste prevention.

All leases shall be subject to the condition that the lessee will, in conducting his exploration, development, and operations, use all reasonable precautions to prevent waste of geothermal resources and other resources found or developed in the leased lands.

§ 3204.3 Readjustment of terms and conditions.

(a) (1) Except as otherwise provided by law, the terms and conditions of any geothermal lease may be readjusted as determined by the authorized officer at not less than 10-year intervals beginning 10 years after the date geothermal steam is produced. Each lease shall provide for such readjustments.

(2) The authorized officer shall give notice to the lessee of any proposed readjustment of the terms and conditions of the lease and the nature thereof, and unless the lessee files with the authorized officer an objection to the proposed terms and conditions or relinquishes the lease within 30 days after receipt of such notice, the lessee shall be deemed conclusively to have agreed to such terms and conditions. If the lessee files objections, and agreement cannot be reached between the authorized officer and the lessee within a period of 60 days, the lease may be terminated by either party, subject to the provisions of § 3000.4 of this chapter. If the lessee files objections to the proposed readjusted terms and conditions, the existing terms and conditions, except for those concerning rental and royalty rates, will remain in effect until there has been an agreement between the authorized officer and the lessee on the new terms and conditions to be applied to the lease or until the lease is terminated. The readjustment of any terms concerning rental and royalty rates will be subject to § 3205.3.

(b) Any readjustment of the terms and conditions of any lease of lands withdrawn or acquired in aid of a function of a Federal department or agency may be made only with the approval of that other agency.

§ 3204.4 Reservation to the United States of oil, hydrocarbon gas, and helium.

The United States reserves the ownership of and the right to extract oil, hydrocarbon gas, and helium from all geothermal resources produced from lands leased under the Act. Whenever the right

to extract oil, hydrocarbon gas, and helium, from geothermal resources produced from such lands is exercised, it shall be exercised so as to cause no substantial interference with the production of geothermal resources from such lands.

§ 3204.5 Compensation for drainage; compensatory royalty.

(a) Upon a determination by the Supervisor that lands owned by the United States are being drained of geothermal resources by wells drilled on adjacent or cornering lands, the authorized officer may execute agreements with the owners of adjacent or cornering lands whereby the United States, or the United States and its lessees, shall be compensated for such drainage, such agreements to be made with the consent of any lessee affected thereby. The precise nature of any agreement will depend on the conditions and circumstances involved in the particular case.

(b) Where land in any lease is being drained of its geothermal resources by a well either on a Federal lease issued at a lower rate of royalty or on land not the property of the United States, the lessee must drill and produce all wells necessary to protect the leased lands from drainage. In lieu of drilling such wells, the lessee may, with the consent of the Supervisor, pay compensatory royalty in the amount determined in accordance with 30 CFR Part 270.

§ 3204.6 Patented lands.

The terms and conditions of any geothermal resource lease for lands conveyed by the United States subject to a reservation to the United States of geothermal resources may be readjusted upon notification to the surface owner.

Subpart 3205—Service Charges, Rentals and Royalties.

§ 3205.1 Payments.

§ 3205.1–1 Form of remittance.

Remittances required under these regulations may be made by cash payment, check, certified check, bank draft, bank cashier's check, or money order. All remittances will be deposited as received.

§ 3205.1–2 Where submitted.

(a) *Rentals on nonproducing leases.* Rentals under all nonproducing leases issued shall be paid at the proper BLM office. All remittances to the Bureau of Land Management shall be made payable to the Bureau of Land Management.

(b) *Other payments.* All royalties on producing leases, communitized leases in producing well units, unitized leases in producing unit areas, leases on which compensatory royalty is payable and all payments under easements for directional drilling are to be paid to the Supervisor. All remittances to the Supervisor shall be made payable to the U.S. Geological Survey.

§ 3205.2 Service charges.

(a) *Competitive lease applications.* No service charge is required.

(b) *Noncompetitive lease applications.* Applications for noncompetitive leases must be accompanied by a nonrefundable service charge of $50 for each application.

(c) *Assignments.* Applications for approval of an assignment of a lease or interest therein must be accompanied by a nonrefundable service charge of $50 for each application.

(d) *Nominations.* No service charge is required.

§ 3205.3 Rentals and royalties.

§ 3205.3–1 Payment with application.

Each application, except an application filed pursuant to Subpart 3221, of this part, must be accompanied by payment of the first year's rental of not less than $1 per acre or fraction thereof based on the total acreage included in the application. An application accompanied by a payment of the first year's rental which is deficient by not more than 10 percent will be approved by the authorized officer provided all other requirements are met, but, if the additional rental is not paid within 30 days from notice, the application or the lease, if issued, will be canceled.

§ 3205.3–2 Payment of annual rental.

(a) Annual rental in the amount specified in the lease which shall be not less than $1 per acre or fraction thereof must be paid in advance and must be received by the proper BLM office on or before the anniversary date of the lease. If there is no well on the leased lands capable of producing geothermal resources in commercial quantities, the failure to pay rental on or before the anniversary date shall terminate the lease by operation of law, except as provided by § 3245.2.

(b) If, on the anniversary date of the lease, less than a full year remains in the lease term, the rentals shall be payable in the same proportion as the period remaining in the lease term is to a full year. The rentals shall be prorated on a monthly basis for the full months, and on a daily basis for the fractional month remaining in the lease term. For the purpose of prorating rentals for a fractional month, each month will be deemed to consist of 30 days.

(c) If the term of a lease for which prorated rentals have been paid is further extended to or beyond the next anniversary date of the lease, rentals for the balance of the lease year shall be due and payable on the 1st day of the first month following the date through which the prorated rentals were paid. If the rentals are not paid for the balance of the lease year, the lease will be subject to cancellation. However, if the anniversary date occurs before the end of the notice period, the rental for the following lease year shall nevertheless be due on the anniversary date and failure to pay the full rental for that year on or before that date shall cause the lease to terminate automatically by operation of law except as provided by § 3245.2. The lessee shall not be relieved of liability for rental due for the balance of the previous lease year.

(d) If the payment is due on a day in which the proper BLM office to receive payment is not open, payment received on the next official working day will be deemed to be timely.

§ 3205.3–3 Escalating rental rates.

To encourage the orderly and timely development of geothermal leases, all leases issued pursuant to the regulations in this Group will provide that, beginning with the sixth year and for each year thereafter until the lease year beginning on or after the commencement of production of geothermal resources in commercial quantities, the rental will be set by the authorized officer as the amount of rental for the preceding year plus an additional rental of $1 per acre, but the authorized officer may, upon a showing of sufficient justification by the lessee, waive the payment of all or any portion of the additional rental.

§ 3205.3–4 Fractional interests.

Rentals, minimum royalties, and royalties payable for lands in which the United States owns an undivided fractional interest shall be in the same proportion to the rentals, minimum royalties, and royalties provided for in § 3205.3, as the undivided fractional interest of the United States in the geothermal resources is to the full geothermal resources interest.

§ 3205.3–5 Royalty on production.

Royalty shall be paid at the following rates on geothermal resources:

(a) A royalty, as set forth in the lease, of not less than 10 per centum and not more than 15 per centum of the amount or value of steam, or any other form of heat or energy derived from production under the lease and sold or utilized by the lessee or reasonably susceptible to sale or utilization by the lessee; (b) a royalty, as set forth in the lease, of not more than 5 per centum of any byproduct derived from production under the lease and sold or utilized or reasonably susceptible of sale or utilization by the lessee, except that as to any byproduct which is a mineral named in section 1 of the Mineral Leasing Act of February 25, 1920, as amended (30 U.S.C. 181), the rate of royalty for such mineral shall be the same as that provided in that Act and the maximum rate of royalty for such mineral shall not exceed the maximum royalty applicable under that Act; (c) In no event shall the royalty on any producing lease for any lease year, commencing with the lease year beginning on or after the commencement of production in commercial quantities, be less than $2 per acre or fraction thereof, and this minimum royalty, in lieu of rental, shall be payable at the expiration of each lease year.

§ 3205.3–6 Royalty on commercially demineralized water.

All geothermal leases issued pursuant to the provisions of this group shall provide for the payment to the lessor of a royalty on commercially demineralized water at a rate to be specified in the

lease of not more than 5 per centum of the value of such commercially demineralized water that has beeen sold or utilized by the lessee or is reasonably susceptible of sale or utilization by the lessee, except that no payment of a royalty will be required on such water if it is used in plant operation for cooling or in the generation of electric energy or otherwise.

§ 3205.3–7 Waiver, suspension or reduction of rental or royalty.

(a) The authorized officer may waive, suspend, or reduce the rental or royalty for any lease or portion thereof in the interests of conservation and to encourage the greatest ultimate recovery of geothermal resources if he determines that this is necessary to promote development or that the lease cannot be successfully operated under the lease terms. No waiver, suspension or reduction of rental or royalty will be granted where the only reason for the request for such relief is the unavailability of power generating facilities to utilize the geothermal steam.

(b) An application hereunder shall be filed in triplicate with the Supervisor, and must: (1) Contain the serial number of the leases and the names of the lessee and operator; (2) show the number, location, and status of each well that has been drilled, a tabulated statement for each month covering a period of not less than 6 months prior to the date of filing the application of the aggregate amount of production subject to royalty computed in accordance with the operating regulations, the number of wells counted as producing each month, and the average production per well per day; (3) contain a detailed statement of expenses and costs of operating the lease, the income from the sale of any leased products and all facts tending to show whether the wells can be successfully operated using the royalty or rental fixed in the lease; and (4) where the application is for a reduction in royalty, furnish full information as to whether royalties or payments out of production are paid to others than to the United States, the amounts so paid, and the efforts made to reduce them. The applicant must also file agreements of the holders to a comparable reduction of all other royalties from the leasehold to an aggregate not in excess of one-half the Government royalties.

§ 3205.3–8 Application for and effect of suspension of operations and production.

(a) Applications by lessees for suspensions of operations or production, or both, under a producing geothermal lease (or for relief from any drilling or producing requirements of such a lease) shall be filed in triplicate with the Supervisor, who is authorized to act on applications filed pursuant to this section and to terminate suspensions which have been or may be granted. Complete information must be furnished showing the necessity of the relief sought.

(b) A suspension shall take effect as of the time specified in the order of the Supervisor. Rental or minimum royalty payments will be suspended during any period of suspension of all operations and production directed, or assented to, by the Supervisor, beginning with the first day of the lease month in which the suspension of operations and production becomes effective or, if the suspension of operations and production becomes effective on any date other than the first day of a lease month, beginning with the first day of the lease month following such effective date. The suspension of rental or minimum royalty payments shall end on the first day of the lease month in which operations or production is resumed. Where rentals are creditable against royalties and have been paid in advance, proper credit will be allowed on the next rental or royalty due under the lease.

(c) No lease shall be deemed to expire by reason of a suspension of either operations or production, pursuant to any order or assent of the Supervisor.

(d) If there is a well on the leased premises capable of producing geothermal resources and all operations and production are suspended pursuant to any order of the Supervisor, approval of recommencement of drilling operations will terminate the suspension as to operations but not as to production, and will terminate both the period of suspension of rental and minimum royalty payments provided in paragraph (b) of this section and the period of suspension for which an equivalent extension will be granted. However, as provided in paragraph (c) of this section, the lease will not be deemed to expire so long as the suspension of operations or production remains in effect.

(e) The relief authorized under this section may also be obtained for any leases included within an approved unit or cooperative plan of development and operation.

(f) See 30 CFR 270.17 for regulations concerning action of the Supervisor on applications filed pursuant to this section.

§ 3205.3–9 Readjustments.

The rentals and royalties of any geothermal lease may be readjusted at not less than 20-year intervals beginning 35 years after the date geothermal steam is produced as determined by the Supervisor. In the event of any such readjustment neither the rental nor royalty paid during the preceding period shall be increased by more than 50 per centum, and in no event shall the royalty payable exceed 22½ per centum. Each geothermal lease shall provide for such readjustment. The Supervisor will give notice of any proposed readjustment of rental or royalties. Unless the lessee relinquishes the lease within 30 days after receipt of such notice, he shall conclusively be deemed to have agreed to such terms and conditions. If the lessee files a protest, and no agreement can be reached between the authorized officer and the lessee within a period of 60 days, the lease may be terminated by either party, subject to the provisions of § 3000.4 of this chapter. If the lessee files a protest to the proposed readjusted terms and conditions, the existing terms and conditions will remain in effect until there has been an agreement between the authorized officer and the lessee on the new terms and conditions to be applied to the lease or until the lease is terminated, except payments of any proposed readjusted rentals and royalties must be paid in the timely manner prescribed in these regulations and may be paid under protest. The readjusted terms and conditions will be effective as of the end of the term being adjusted.

§ 3205.4 Rental and minimum royalty liability of lands committed to cooperative or unit plans.

§ 3205.4–1 Prior to production.

All lands within any lease committed to an approved cooperative or unit plan shall at all times prior to production on any of the lands so committed remain liable for rental in accordance with § 3205.3–3.

§ 3205.4–2 After production.

As soon as production is obtained on or for any lands included in an approved cooperative or unit plan those lands which are included within the participating area of the producing well shall become liable for royalties in accordance with Subpart 3205. All other unitized lands, shall remain liable for rental in accordance with § 3205.3–3.

Subpart 3206—Lease Bonds

§ 3206.1 Types of bonds and filing.

§ 3206.1–1 Types of bonds.

(a) Bonds shall be either corporate surety bonds or personal bonds except that bonds with individual sureties may be furnished for the protection of the entryman or owner of the surface rights.

(b) Lease compliance bond. The applicant for a noncompetitive lease or the successful bidder for a competitive lease must furnish, prior to the issuance of the lease, and thereafter maintain a corporate surety bond of not less than $10,000 conditioned on compliance with all the terms of the lease.

(c) Protection bond. A lessee will be required prior to entry on the leased lands to furnish and maintain a bond of not less than $5,000 for indemnification for all damages occasioned to persons or property as the result of lease operations.

§ 3206.1–2 Filing of bonds.

A single original copy of the bond on forms approved by the Director must be filed in the proper BLM office. Bonds may be filed with a noncompetitive lease application to expedite action thereon, or within 30 days after receipt of notice by the applicant of the bond requirement, or as required and directed by the authorized officer. For unit bond forms see 30 CFR Part 271.

§ 3206.2 Termination of period of liability.

The period of liability of any bond will not be terminated until all lease terms and conditions have been fulfilled.

§ 3206.3 Operators bond.

An operator, or, if there are more than one for different portions of the lease, each operator, shall furnish a corporate surety bond or bonds in an amount prescribed by the Supervisor.

§ 3206.4 Qualified corporate sureties.

Treasury lists. A list of companies holding certificates of authority from the Secretary of the Treasury under the Act of July 30, 1947 (6 U.S.C. 6–13), as acceptable sureties on Federal bonds is published in the FEDERAL REGISTER annually.

§ 3206.5 Nationwide bond.

In lieu of bonds required under any of the preceding paragraphs, the holder of leases or of operating agreements approved by the Department or holder of operating rights by virtue of being designated operator or agent by the lessee pending departmental approval of operating agreements may furnish a bond in an the amount of which must be not less than for $150,000 for full nationwide coverage for all geothermal leases.

§ 3206.6 Statewide bond.

In lieu of any of the bonds required by the preceding paragraphs, the holder of leases or of operating agreements approved by the Department or holder of operating rights by virtue of being designated operator or agent by the lessee pending departmental approval of operating agreements, may furnish a statewide bond, applicable to the State in which the leases are situated, the amount of which must be at the rate of not less than $50,000 for each unit of coverage.

§ 3206.7 Default.

§ 3206.7–1 Payment by surety.

Where upon a default the surety makes payment to the Government of any indebtedness due under a lease, the face amount of the surety bond and the surety's liability thereunder shall be reduced by the amount of such payment.

§ 3206.7–2 Penalty.

Thereafter, upon penalty of cancellation of all of the leases covered by that bond, the principal shall post a new nationwide bond in the amount of $150,000 or a unit bond, as the case may be, within 6 months after notice, or within such shorter period as the authorized officer may fix. However, in lieu thereof, the principal may within that time file separate bonds for each lease.

§ 3206.8 Applicability of provisions to existing bonds.

The provisions of these regulations may be made applicable to any oil and gas nationwide or statewide bond in force at the effective date of these regulations by filing in the proper BLM office a written consent to that effect and an agreement to be bound by the provisions hereof executed by the principal and the surety. Upon receipt thereof the bond will be deemed to be subject to the provisions of these regulations.

Subpart 3207—[Reserved]

Subpart 3208—[Reserved]

Subpart 3209—Geothermal Resources Exploration Operations

§ 3209.0–1 Purposes.

(a) The purpose of the regulations in this Subpart 3209 is to establish procedures to be followed in conducting exploration operations on the public land for geothermal resources. The regulations in this subpart are not applicable to exploration operations conducted pursuant to a geothermal resources lease.

(b) The rights obtained under this subpart do not include an exclusive right to prospect for geothermal resources on the land described in a Notice of Intent or any preference right to a geothermal resources lease.

§ 3209.0–2 Objectives.

The objectives of the regulations in this Subpart 3209 are to encourage exploration of the public lands for geothermal resources in a manner that is consistent with the management policy set forth in § 1725.3 of this chapter. No exploration operations will be allowed if the authorized officer determines that such exploration operations would be inconsistent with that policy. The authorized officer may suspend or terminate exploration operations upon due notice to the operator at any time if he determines that there is non-compliance with the terms and conditions of the notice of intent.

§ 3209.0–5 Definitions.

As used in this subpart:

(a) "Exploration operations" means any activity relating to the search for evidence of geothermal resources which requires physical presence upon public lands and which may result in damage to public lands or resources thereon. It includes, but is not limited to, geophysical operations, drilling of shallow temperature gradient wells, construction of roads and trails, and cross-country transit by vehicle over public lands. It does not include the casual use of public lands for geothermal resources exploration. It does not include core drilling for subsurface geologic information, except drilling of shallow temperature gradient wells, or drilling for geothermal resources; these activities will be authorized only by the issuance of a geothermal resources lease. The regulations in this Subpart, however, are not intended to prevent drilling operations necessary for placing explosive charges for seismic exploration, nor do they affect the exclusive right of a lessee to drill for geothermal resources upon the land subject to his lease.

(b) "Notice of Intent" means a "Notice of Intent and Permit to Conduct Exploration Operations (Geothermal Resources)."

(c) "Public lands" means lands owned by the United States and administered by the Bureau of Land Management, including retained mineral interest in lands, title to which has passed from the United States.

(d) "Casual use" means activities that involve practices which do not ordinarily lead to any appreciable disturbance or damage to lands, resources, and improvements. For example, activities which do not involve use of heavy equipment or explosives and which do not involve vehicle movement except over established roads and trails are "casual use."

§ 3209.1 Notice of intent and permit to conduct exploration operations (Geothermal Resources).

§ 3209.1–1 Application.

(a) *Forms and where filed.* Any persons desiring to conduct exploration operations under the regulations of this subpart shall, prior to entry upon the lands, file for approval with the authorized officer for the district in which the public lands are located a Notice of Intent on a form approved by the Director.

(b) *Requirements.* The Notice of Intent will contain the following:

(1) The name and address, including zip code, both of the person, association, or corporation for whom the operations will be conducted and of the person who will be in charge of the actual exploration activities;

(2) A statement that the signers agree that exploration operations will be conducted pursuant to the terms and conditions listed on the approved form;

(3) A brief description of the type of operations which will be undertaken;

(4) A description of the lands to be explored by township;

(5) A map or maps, available from state or Federal sources, showing the lands to be entered or disturbed by the proposed exploration operations; and

(6) The approximate dates of the commencement and termination of exploration operations.

§ 3209.1–2 Review of Notice of Intent.

The authorized officer will either approve or disapprove a Notice of Intent as promptly as practicable, but in any event within 30 calendar days after the date of the filing of the Notice of Intent. If the authorized officer shall disapprove a Notice of Intent, he shall explain in writing to the applicant the reasons for disapproval.

§ 3209.2 Exploration operations.

No exploration operations will be conducted on public lands except pursuant to the terms of a Notice of Intent which has been approved by the authorized officer.

§ 3209.3 Completion of operations.

Upon completion of the exploratory operations, there shall be filed with the authorized officer a "Notice of Completion of Exploration Operations." Within 90 days after the filing of such "Notice of Completion," the authorized officer shall notify the party who had conducted

the operations whether there has been compliance with all of the terms and conditions set out by the regulations in this Subpart and in the Notice of Intent, or whether any additional measures must be taken to rectify any damage to the land, specifying the nature and extent thereof.

§ 3209.4 Bond requirement.

§ 3209.4–1 General.

(a) Simultaneously with the filing of the Notice of Intent, and before the entry is made on the land, the party or parties filing the Notice of Intent must file with the authorized officer a surety company bond for each exploration operation in the amount of not less than $5,000, conditioned upon the full and faithful compliance with all of the terms and conditions of the regulations in this Subpart and of that Notice of Intent.

(b) A party will be excused from compliance with the requirements of paragraph (a) of this section if he possesses either a nationwide bond in the amount of not less than $50,000 covering all exploration operations or a statewide bond in the amount of not less than $25,000 covering all exploration operations in the State in which the lands on which he has filed the "Notice of Intent" are situated.

(c) In addition to the bond required by paragraph (a), before entry is made on the land, the party or parties filing the "Notice of Intent" must furnish and maintain bonds in the amount of not less than $1,000 for the protection of each owner or holder of surface rights or rights to surface resources.

§ 3209.4–2 Riders to existing bond forms.

Nationwide and statewide bonds. Holders of nationwide and statewide oil and gas exploration bonds shall be permitted, in lieu of furnishing additional bonds other than those required by § 3209.4–1(c), to amend their bonds to include geothermal resources exploration operations.

§ 3209.4–3 Termination of period of liability.

The authorized officer will not give his consent to the cancellation of the bond if an individual bond was submitted or to the termination of the period of liability if a State or nationwide bond was submitted, unless and until there has been compliance with all of the terms and conditions of the Notice of Intent. Should the authorized officer fail to notify the party within 90 days from the filing of "Notice of Completion" that all terms and conditions have been complied with or that additional corrective measures must be taken to rehabilitate the land, the period of liability under an individual bond or the period of liability for a particular exploration operation under a State or nationwide bond shall automatically terminate on the 91st day.

PART 3210—NONCOMPETITIVE LEASES

Subpart 3210—Noncompetitive Leases; General

Subpart 3211—Bureau Motion, Lands Previously Leased for Geothermal Resources

Subpart 3210—Noncompetitive Leases; General

§ 3210.1 Availability of land.

(a) Applications to lease, except for those filed pursuant to Part 3230, of this chapter, filed prior to the effective date of these regulations are unacceptable and will be returned summarily without earning any priority.

(b) Lands and deposits subject to disposition under this part which are not within any KGRA will be available for leasing after the effective date of these regulations. Lands which are available for noncompetitive leasing and which were included in cancelled, relinquished, expired, or terminated leases shall be available for leasing only subject to the provisions of Subpart 3211. All other lands available for noncompetitive leasing will be available for leasing only subject to the provisions of this Subpart 3210. All applications to lease the same lands which are filed between the effective date of these regulations and 30 days following that time will be considered to have been filed simultaneously, and the respective priority of the various applications will be determined in accordance with § 3210.3. In other respects the first 30 days after the effective date of these regulations shall be treated as an application filing period as provided in § 3210.2–2.

(c) Final action will not be taken on any application filed after the initial 30-day period until final action has been taken on all applications filed during that period.

§ 3210.2–1 Application.

An application for a lease must be filed on a form approved by the Director in the proper BLM office in duplicate for public lands and in triplicate for acquired lands. The application must be submitted in a sealed envelope marked "Application for lease pursuant to 43 CFR 3210". An application will be considered filed when it is received in the proper office during business hours. The application must include the following:

(a) The applicant's name and address;

(b) A statement of applicant's citizenship and qualifications;

(c) A complete and accurate description of the lands applied for, which must include all available lands, including reserved geothermal resources, within a surveyed or protracted section;

(d) A proposed plan which shall include: (1) A map, or maps, available from State or Federal sources, showing the topography of the land applied for, on which the applicant shall show drainage patterns, present road and trail locations, present utility systems, proposed road and trail location, proposed well locations and potential surface disturbance, and (2) a narrative statement setting forth his proposed plan and methods for diligent exploration. Such plan shall provide for a program of diligent exploration as defined in § 3203.5 of this subchapter.

The narrative statement shall also describe the measures proposed to be taken to prevent or control fire, soil erosion, pollution of surface and ground water, damage to fish and wildlife or other natural resources, air and noise pollution and hazards to public health and safety during lease activities. However, the proposed plan required by this paragraph need not be submitted with the application during the initial 30-day simultaneous filing period provided by § 3210.1(b) or during any application filing period pursuant to § 3210.2–2, but must be submitted when required by the authorized officer; and

(e) A statement of interest, direct or indirect, in other Federal geothermal leases or applications in the same State. Such total interest may not exceed 20,480 acres.

§ 3210.2–2 Submission of applications.

Except for applications filed during the first 30 days after the effective date of these regulations, applications for leases pursuant to this Part 3210 shall be submitted only during application filing periods. An application filing period shall begin on the first working day of each month and shall end at the close of business on the last working day of that month. The first application filing period shall begin on the first working day of the month following the conclusion of the initial 30 day filing period provided in § 3210.1(b). No applicant shall file during the same application filing period a second application which overlaps any of the land covered by his first application. When an application is filed with the authorized officer, the date and time of filing shall be stamped on the envelope. The envelope containing the application shall remain sealed until the end of the application filing period during which the application is filed. On the first working day following the end of the application filing period all applications shall be opened, and it will be determined which applications are for lands included in a KGRA. In determining whether land included in an application is a KGRA because of competitive interest, no application sub-

mitted during any subsequent application filing period will be considered. Applications for land determined to be KGRA will be rejected. All other applications will be assigned priority according to the date and time of filing. If any application covers both land within a KGRA and land outside a KGRA, the applicant will be granted the opportunity to amend his application to exclude the portion included in a KGRA, and his amended application will be assigned priority according to the date and time of filing of his original application, but must comply with all other requirements of these regulations.

§ 3210.2–3 Withdrawal of application

An application may not be withdrawn, either in whole or in part, unless the request is received by the proper BLM office before the lease or an amendment of the lease, whichever covers the land described in the withdrawal, has been signed on behalf of the United States even though the effective date of the lease is subsequent to the date of filing of the withdrawal, except where a separate conflicting lease has been signed on behalf of the United States covering the land described in the withdrawal.

§ 3210.2–4 Amendment to lease.

If any of the land applied for was open to filing when the application was filed but is omitted from the lease for any reason and thereafter becomes available for noncompetitive leasing, the original lease will be amended to include the omitted land unless, before the issuance of the amendment, the proper BLM office receives a withdrawal of the lessee's application with respect to such land or such omitted lands have been determined to be within a KGRA. The lease term for the land added by such an amendment shall be the same as if the land had been included in the original lease when it was issued.

§ 3210.3 Determination of priorities.

(a) No lease shall be issued before final action has been taken on (1) any prior application to lease the land, (2) any subsequent application to lease the land that is based upon a claimed preferential right, and (3) any petition for the renewal or reinstatement of an existing or former lease on the land.

(b) Where a lease is issued before final action has been taken on such applications and petitions, it shall be canceled, and the advance rental returned, after due notice to the lessee, where the applicant or petitioner is found to be qualified and entitled to receive a lease of the land.

(c) Applications for lease received in the mail or delivered on the same day will be deemed to have been simultaneously filed, and the right of priority and the order of processing will be determined by a public drawing.

(d) Prior to the issuance of any lease, a determination shall be made as to whether or not the lands are within a KGRA. Applications for lands determined to be within any KGRA will be rejected.

§ 3210.4 Rejections.

If, after the filing of an application for a noncompetitive lease and before the issuance of a lease, or amendment thereto, pursuant to that application, the land embraced in the application becomes included within a KGRA, the application will be rejected as to such KGRA lands. The authorized officer retains discretion to reject an application for a noncompetitive lease even though the tract for which application is made is not determined to be within a KGRA.

Subpart 3211—Bureau Motion—Land Previously Leased for Geothermal Resources

§ 3211.1 Releasing of formerly leased lands.

Lands available for noncompetitive leasing in canceled or relinquished leases or in leases which expire by operation of law at the end of their primary or extended terms or in leases which terminate by operation of law for nonpayment of rental pursuant to 30 U.S.C. sec. 1004, shall be subject to further leasing only in accordance with the provisions of this section. From time to time the authorized officer will publish in the FEDERAL REGISTER, post in each proper BLM office, and provide appropriate news coverage of:

(a) A list of leasing units composed of lands which are available for noncompetitive leasing and which were in canceled, expired, relinquished, or terminated leases.

(b) An announcement that applications for leases on such lands will be received after a specific hour and date and that any applications filed during a specified simultaneous filing period beginning at that time will be regarded as simultaneously filed;

(c) The address of the proper BLM office where applications must be filed and where the terms and conditions under which the lease will be issued are available; and

(d) Requirements for a complete application, indicating that the proposed plan of operation, as required by § 3210.2–1(d), will not be required until there has been a drawing and a consequent determination of priority, but must be filed before a lease can be issued.

§ 3211.2 Applications during simultaneous filing periods.

(a) An application shall conform to the requirements of 43 CFR 3210.2–1, except as provided below.

(b) Only one complete leasing unit, identified by unit number, may be included in an application. Lands not on the published list may not be included in the application.

(c) An applicant is permitted to file only one application for each numbered unit on the posted list. Submission of more than one application by or on behalf of the applicant for any unit on the posted list will result in the disqualification of all applications submitted by that applicant for the drawing to be held for that particular unit.

(d) The application must be accompanied by a signed statement that the applicant will furnish the information required by these regulations within 15 days after notification that his application is the only one for the tract, or that he is the successful drawee.

(e) Each application filed during a simultaneous filing period must be submitted in a sealed envelope marked "Application for a lease pursuant to 43 CFR subpart 3211". The envelope will remain sealed until the end of the 30-day simultaneous filing period, at which time the application will be time-stamped simultaneously and serialized. A public drawing of all applications received during the simultaneous 30-day period will be held to determine respective priorities and order of processing.

(f) Applications filed during a simultaneous filing period are subject to the classification criteria established in § 3200.0–5(k) and will be considered as all filed the same day.

(g) The requirements of § 3210.2–1(d) need not be satisfied for a complete application during the 30-day simultaneous filing period or during any future designated simultaneous filing period. Such data must be submitted by the successful drawee when requested by the authorized officer.

(h) Each application must be accompanied by the service charge of $50. The first year's advance rental need not be submitted with the application. A lease will be issued to the first drawee qualified to receive a lease upon payment of the first year's rental. Rental must be received in the proper BLM office within fifteen days from the date of receipt of notice that such rental is due. The drawee failing to submit the rental payment within the time allowed will be automatically disqualified to receive the lease, and consideration will be given to the application of the drawee having the next highest priority in the drawing.

§ 3211.3 Issuance of leases for units on posted list.

(a) If more than one application is received during the simultaneous filing period for the same unit on the list posted pursuant to § 3211.1(a), all applications on that unit filed during that period will be considered simultaneously filed. Priority of filing for such units will be determined by a public drawing. Three applications will be drawn for each unit.

If the lands are determined not to be within any KGRA, a lease may be issued to the successful drawee upon his compliance with all applicable regulations, including those in Subpart 3210 of this part.

(b) If only one application is filed during the simultaneous filing period on a unit on the list posted pursuant to § 3211.1(a), a lease on that unit, if the land is not included within any KGRA, may be issued to the applicant, upon his compliance with all applicable regulations, including those in Subpart 3210 of this part.

(c) If no application is filed on a unit on the list posted pursuant to § 3211.1

(a) within the prescribed simultaneous filing period, the land in that unit, if not with a KGRA, will become available for leasing in accordance with Subpart 3210 of this part.

PART 3220—COMPETITIVE LEASES

Subpart 3220—Competitive Leases; General

Subpart 3220—Competitive Leases; General

§ 3220.1 General.

(a) Lands within a KGRA, except as provided under § 3201.1, will be available for leasing on the effective date of these regulations.

(b) The authorized officer will accept nominations to lease, or may on his own motion from time to time call for nominations to lease. Nominations may be withdrawn at any time.

§ 3220.2 Nominations.

(a) Nominations will be submitted on a card approved by the Director.

(b) A nomination must be filed in the proper BLM office in duplicate for public lands and triplicate for acquired lands and must include the following:

(1) The nominator's name and address;

(2) A statement of citizenship and qualifications for lease;

(3) A description of the lands; and

(4) A statement of the interests, direct or indirect, held in other Federal geothermal leases or applications in the same State.

§ 3220.3 Publication of notice of lease sale.

Where the Secretary determines to offer lands for competitive leasing he will publish a notice of lease sale in a newspaper of general circulation in the area in which the lands to be leased are located once a week for 4 consecutive weeks, or for such other period as he may direct.

§ 3220.4 Contents of notice of lease sale.

The notice will specify the time and place of sale, the manner in which bids may be submitted, the description of the lands, and the terms and conditions of the sale, including royalty and rental rates.

The notice will indicate the proper BLM office where the terms and conditions under which the lease will be issued are available. The notice will also indicate that the proposed plan of operation, as required by § 3210.2-1(d), must be filed before a lease can be issued.

§ 3220.5 Bidding requirements.

(a) A separate identified sealed bid must be submitted for each lease unit. Each bidder must submit with his bid a certified or cashier's check, bank draft, money order or cash in the amount of one-half of the amount bid together with proof of qualifications as required by these regulations.

(b) All bidders are warned against violation of the provisions of Title 18 U.S.C. section 1860 prohibiting unlawful combination or intimidation of bidders.

§ 3220.6 Award of lease.

(a) All sealed bids shall be opened at the place, date, and hour specified in the notice. No bids will be accepted or rejected at that time.

(b) Leases will be awarded to the highest responsible qualified bidder, except as required under Part 3230.

(c) The right to reject any and all bids is reserved. If the authorized officer fails to accept the highest bid for a lease within 30 days after the date on which the bids are opened (or such longer period as may be needed to comply with § 3230.1-6), all bids for that lease will be considered rejected. Deposits on rejected bids will be returned.

(d) If the lease is awarded, three copies of the lease will be sent to the successful bidder who shall be required to execute them within 30 days from receipt thereof, to pay the first year's rental, the balance of the bonus bid, file the required bond or bonds, and submit the proposed plan of operation as required by § 3210.-2-1(d). When the three copies of the lease are executed by the successful bidder and returned to the authorized officer, the lease will be executed by the authorized officer and a copy will be mailed to the successful bidder.

(e) If the successful bidder fails to execute the lease or otherwise comply with the applicable regulations, his deposit will be forfeited and disposed of as provided in section 20 of the Act. In this event the lands will be reoffered when it is determined, in the opinion of the Secretary, that sufficient interest exists to justify a competitive lease sale.

PART 3230—RIGHTS TO CONVERSION TO GEOTHERMAL LEASES OR APPLICATION FOR GEOTHERMAL LEASES

Subpart 3230—Rights to Conversion to Geothermal Leases or Application for Geothermal Leases; General

Subpart 3230—Rights to Conversion to Geothermal Leases or Application for Geothermal Leases

§ 3230.1 General.

§ 3230.1-1 Rights to conversion to geothermal leases.

Where lands were on September 7, 1965, subject to valid leases or permits issued under the Mineral Leasing Act of 1920, as amended and supplemented (30 U.S.C. 181-287), or the Mineral Leasing Act for Acquired Lands, as amended (30 U.S.C. 351-358), or subject to existing mining claims located on or prior to September 7, 1965, the lessees, permittees, or claimants, or their successors in interest, if qualified to hold geothermal leases, shall have the right, subject to certain limitations as hereinafter provided, to convert such leases, permits or claims to geothermal leases covering the same lands.

§ 3230.1-2 Rights to conversion to applications for geothermal leases.

Where lands were subject to application for leases or permits under the mineral leasing laws referred to in § 3230.1-1 on September 7, 1965, the applicants may, subject to certain limitations as hereinafter provided, convert their applications to applications for geothermal leases having priorities dating from the time of filing such applications under said mineral leasing laws.

§ 3230.1-3 Land in which minerals are reserved to the United States.

Where a right to one of the forms of conversion referred to in § 3230.1-1 or § 3230.1-2 is claimed as to lands the surface of which has passed from Federal ownership but in which the minerals have been reserved to the United States, final action on any claim to conversion rights under section 4 of the Act shall be held in abeyance until such time as the question of title to the geothermal resources in such lands has been resolved pursuant to the provisions of section 21(b) of the Act, unless the Secretary determines that it is in the public interest to make a determination of such claims at an earlier time, subject to the rights, if any, of non-Federal owners.

§ 3230.1-4 Conflicting claims of rights to conversion to geothermal leases, or to applications for geothermal leases.

(a) Where there are conflicting claims of rights to conversion to geothermal leases based upon mineral leases, mineral permits, or mining claims embracing the same land, the date of issuance of the permit or lease or of recordation of the claim shall determine priority.

(b) Where there are rights to conversion to applications for geothermal

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leases based on applications for mineral leases or permits in conflict wth rights to conversion to geothermal leases based upon mining claims embracing the same lands, the date of filing the application or the date of recordation of the mining claim shall determine priority.

§ 3230.1–6 Method of leasing to owners of conversion rights to geothermal leases, or to applications for geothermal leases.

(a) *Lands included within any KGRA*—(1) *Competitive lease.* Where lands have been included within any KGRA prior to the issuance of a lease, the owner of a conversion right to a geothermal lease for such lands shall be entitled to the issuance of a competitive lease only in accordance with the provisions of subparagraph (2) of this paragraph. If the lands subject to a conversion right to a geothermal lease are in part within a KGRA and in part outside a KGRA, the holder of that conversion right shall have the right to divide his conversion right into two separate conversion rights so that he may receive a geothermal lease to the lands within the KGRA only subject to subparagraph (2) of this paragraph and a geothermal lease to the lands not within a KGRA subject to paragraph (b) of this section.

(2) *Preference right.* (i) Lands which have been included within any KGRA shall be leased only by competitive bidding in the manner prescribed in Subpart 3220 of this chapter, except that, in addition, the name and address of the owner of any conversion right to a geothermal lease will be set forth in the lease sale notice.

(ii) The person owning the right to conversion to a geothermal lease shall be informed by written notice of the highest bona fide bid submitted for the lease at the sale. If within thirty (30) days after he has received that written notice, the person owning the right to conversion to a geothermal lease shall inform the authorized officer that he wishes such a lease, pay an amount equal to the highest bona fide bid submitted, pay the rental for the first year, file the required bond or bonds, and submit the data required by § 3210.2–1(d) and (e), a lease will be issued to him.

(iii) Failure of the owner of the right to conversion to a geothermal lease to inform the authorized officer timely will constitute a forfeiture of his conversion rights without further notice to him. In this event, the lease will be offered to the highest bona fide bidder, if otherwise qualified.

(b) *Lands not included within any KGRA—Noncompetitive lease.* Where lands have not been included within any KGRA prior to the issuance of a lease, the owner of a conversion right to a geothermal lease for such lands, if otherwise qualified, shall be entitled to the issuance of a noncompetitive lease for such lands.

(c) *Lands included within a KGRA*—(1) *Application for a lease.* Where lands have been included within a KGRA prior to the issuance of a lease, the owner of a conversion right to an application for a geothermal lease to those lands shall be entitled to receive a competitive geothermal lease only in accordance with the provisions of Subpart 3220 of this part. If the lands subject to a conversion right to a geothermal application are in part within a KGRA and in part outside a KGRA, the holder of that conversion right may amend his application to cover only the land outside the KGRA.

(2) *Preference right.* The owner of a conversion right to an application for a geothermal lease where the lands have been included within a KGEA shall receive no preference right to meet the highest bona fide bid.

(d) *Lands not included within any KGRA*—(1) *Application for a lease.* Where lands have not been included within a KGRA, the owner of a conversion right to an application for a geothermal lease, if otherwise qualified, shall be entitled to convert his right into an application for a non-competitive lease.

(2) *Preference right.* The owner of a conversion right to an application for a geothermal lease where the lands have not been included within a KGRA, if otherwise qualified, shall be entitled to the issuance of a non-competitive geothermal lease for such lands in accordance with Subpart 3210 of this part.

§ 3230.1–7 Acreage limitation.

No person shall be permitted to obtain, through conversion of mineral leases or prospecting permits, or applications therefor, or mining claims, leases for more than 10,240 acres, or a lease to any land not included in the lease, permit, application or claim converted, except that any such geothermal lease issued may include some lands not embraced in the lease, permit, application or claim on which the conversion right is based, where a metes and bounds description was used to describe lands in issued leases or permits or in filed applications or mining claim locations. In such event, the metes and bounds description will be conformed by the authorized office to a legal subdivision, to the extent possible.

§ 3230.2 Qualifications.

Persons who believe they are qualified under the Act to convert mineral leases or permits or existing mining claims to geothermal leases and persons who believe they are entitled to convert applications for mineral leases and permits to applications for geothermal leases shall comply with the procedures set forth below.

§ 3230.3 Applications.

§ 3230.3–1 Filing of application.

(a) A written application shall have been filed with the proper BLM office on or before June 22, 1971, pursuant to the notice published in the FEDERAL REGISTER of January 15, 1971, 36 FR 623. If such an application has been filed and does not contain the information specified in § 3230.3–2 hereof, such information must be supplied by the applicant within 60 days of the effective date of these regulations.

(b) Failure to have filed a conversion right application on or before June 22, 1971, will result in the loss of any such rights so claimed.

§ 3230.3–2 Statements required.

(a) An application based on a valid lease or permit referred to in section 3230.1–1 hereof shall include the date of issuance, the State in which the lands are located, and the serial number of the lease or permit. An application based on a mining claim referred to in § 3230.1–1 shall include the name, location, legal description or reference sufficient to identify the lands on the ground, date of location and date and place of recordation of the mining claim (including volume and page), which the applicant seeks to convert to a geothermal lease. An application based on an application for a mineral lease or permit referred to in § 3230.1–1 shall include the date the application for the lease or permit was filed with the Bureau of Land Management and the location of the proper BLM office where the application was filed, and should indicate the serial number assigned to the application.

(b) An application shall include a description of the lands sought to be included in a geothermal lease. If the lands have been surveyed under the public land rectangular survey system, each application shall describe the lands by legal subdivision, section, township, and range. If otherwise officially surveyed, the lands shall be described by the legal description, mining claim survey, or irregular tracts. If the lands have not been so surveyed, but protracted surveys for those lands have been approved and the effective date thereof published in the FEDERAL REGISTER, each application for lands shown on such protracted surveys, filed on or after such effective date, shall describe the lands according to the legal subdivision, section, township, and range shown on the approved protracted surveys. If the lands have not been so surveyed, or included within approved protracted surveys, or it is otherwise appropriate, each application shall describe the lands by metes and bounds, giving courses and distances between the successive angle points on the boundary of the tract, and connected by courses and distances to a monument or to a prominent topographic feature.

(c) An application shall be accompanied by a detailed statement showing: (1) The expenditures made for the exploration, development, or production of geothermal steam by the applicant on lands for which a geothermal lease is sought or on adjoining, adjacent or nearby Federal or non-Federal lands and the date or dates such expenditures were made, (2) the names and current addresses of the persons who actually performed the aforesaid exploration, development, or production work, (3) the geological, geophysical, and engineering data acquired in such exploration, development, and production which

demonstrates, or tends to demonstrate the expenditures claimed, (4) a map showing the location where the expenditures and improvements were made, (5) a proposed plan as required by § 3210.2–1 (e), and (6) a statement that he will be bound by the terms and conditions of a lease, if issued. The applicant shall file such additional information with respect to the application as requested by the authorized officer.

§ 3230.4 Conversion to geothermal leases or to applications for geothermal leases.

§ 3230.4–1 Processing and adjudicating applications.

Application for conversion to geothermal leases or to applications for geothermal leases together with all information and data submitted or requested by the authorized officer pursuant to § 3230.3–2 hereof and any other pertinent available information or data shall be reviewed by the authorized officer for the purpose of determining whether the required showing has been made, and thereafter the authorized officer shall prepare a proposed determination which shall be submitted to the Secretary.

§ 3230.4–2 Approval.

The authorized officer will make a determination that the applicant has or has not satisfactorily shown that he is entitled to receive the grant of a geothermal lease, or application for a geothermal lease.

PART 3240—RULES GOVERNING LEASES

Subpart 3240—Rules Governing Leases

Subpart 3241—Assignments and Transfers

Subpart 3242—Production and Use of Byproducts

Subpart 3243—Cooperative Conservation Provisions

Subpart 3244—Terminations and Expirations

Subpart 3241—Assignments and Transfers

§ 3241.1 Assignments, transfers, interests, qualifications.

§ 3241.1–1 Record title assignments or transfers of leases or undivided lease interests.

(a) The record title of leases may be assigned as to all or part of the leased acreage, except that no assignment will be approved where (1) either the assigned or retained portions created by the assignment would be less than 640 acres, unless the total acreage in the lease being partially assigned is less than 1,280 acres occasioned by includes an irregular subdivision, as provided in § 3203.2 of this part, in which case the assigned and retained portions may be less than 640 acres by an amount which is smaller than the amount by which the area would be more than 640 acres if the irregular subdivision were added, or (2) an undivided interest is created by assignment of a lease containing less than 640 acres, or (3) where the lease being assigned contains 640 acres or more, an undivided interest of less than 10 percent would be created in the leased acreage. An exception to the minimum acreage provision of this section may be made by the Secretary where he finds such exception is necessary in the interest of conservation of the resources.

(b) A working interest or operating right may be assigned, in accordance with this section, *Provided* That the assigned interest or right, divided or undivided, vests in the holder only the right to explore, develop and produce geothermal resources from the leased lands to the extent of not less than the interest assigned.

(c) All requests for approval of any assignment will be reviewed, prior to approval, to adjust environmental terms and conditions where necessary.

§ 3241.1–2 Qualifications.

(a) No assignment will be approved (1) if the assignee or any other party in interest is not qualified to take and hold a lease; (2) if a required bond is not filed; or (3) if the statement of interest required under § 3202.2–1(a) is not filed.

(b) an assignment to a minor other than an heir or devisee of a lessee will not be approved.

(c) The assignment must be accompanied by a signed statement by the assignee either (1) that he is the sole party in interest in the assignment, or (2) setting forth the names and qualifications of the other parties holding interests in the lease. Where the assignee is not the sole party in interest, separate statements must be signed by each of the other parties and by the assignee setting forth the nature and extent of the interest of each party and the nature of the agreement between them. These separate statements must be filed in the proper BLM office not later than 15 days after the filing of assignment.

(d) Where an attorney-in-fact or agent signs, on behalf of the assignor or assignee, the instrument of transfer or the application for approval, evidence of the authority of the attorney-in-fact or agent to sign such assignment or application must be furnished to the authorized officer.

(e) In order for the heir or devisee of the deceased holder of a lease, an operating agreement, or an overriding royalty interest in a producing lease, to be recognized by the authorized officer as the holder of that lease, agreement or interest, the appropriate showing required under the regulations in § 3202.2–6 must be furnished to the authorized officer.

§ 3241.2 Requirements for filing of assignments or transfers.

§ 3241.2–1 Place of filing and service charge.

A request for approval of any assignment or other instrument of transfer of a lease or interest therein must be filed in the proper BLM office and accompanied by a nonrefundable service charge of $50. An application request not accompanied by payment of such a service charge will not be accepted for filing.

§ 3241.2–2 Number of copies required.

Three copies of all instruments of assignment or transfer, and a single copy of any additional information required by § 3202.2. Relating to citizenship or qualifications of corporations must be filed in the proper BLM office.

§ 3241.2–3 Time of filing assignments, transfers of leases, or undivided lease interests.

(a) Any instrument of transfer of a lease or of an interest therein, including an assignment of working interests, operating agreements, and operating rights, must be filed in the proper BLM office for approval within 90 days from the date of execution of that instru-

ment and must contain all of the terms and conditions agreed upon by the parties thereto, together with evidence and statements similar to that required of an applicant under these regulations in this group.

(b) A separate instrument of assignment must be filed in the proper BLM office for each geothermal lease involving transfers of record title. When transfers to the same person, association, including partnerships, or corporation involve more than one geothermal lease, one request for approval and one showing as to the qualifications of the assignee will be sufficient.

§ 3241.2–4 **Forms and statements.**

A form approved by the Director, or unofficial copies of that form in current use, must be used for transfers and requests for approval referred to in this section and must be filed in duplicate for public lands and in triplicate where acquired lands are involved. The approved form may be used for an assignment which affects a transfer of the record title to all or part of a geothermal lease, but it is not to be used for any other type of transfer. The application for assignment shall be deemed to be approved upon execution by the authorized officer.

§ 3241.2–5 **Description of lands.**

Each instrument of transfer must describe the lands involved in the same manner as described in the lease.

§ 3241.3 **Bonds.**

Where an assignment does not create separate leases, the assignee, if the assignment so provides, may become a joint principal on the bond with the assignor. Any assignment which does not convey the assignor's record title in all of the lands in the lease must also be accompanied by consent of his surety to remain bound under the bond of record as to the lease retained by said assignor, if the bond, by its terms, does not contain such consent. If a party to the assignment has previously furnished a nationwide or statewide bond, no additional showing by such party is necessary as to the bond requirement.

§ 3241.4 **Approval.**

Upon approval, an assignment shall be effective as of the first day of the lease month following the date of filing of the assignment required by this Subpart in the proper BLM office.

§ 3241.5 **Continuing responsibility.**

(a) The assignor and his surety will continue to be responsible for the performance of any obligation under the lease until the assignment is approved.

(b) Upon approval, the assignee and his surety shall be responsible for the performance of all lease obligations notwithstanding any terms in the assignment to the contrary.

§ 3241.6 **Production payments.**

If payments out of production are reserved, a statement must be submitted stating the details as to the amount, method of payment, and other pertinent items.

§ 3241.7 **Overriding royalty interests.**

§ 3241.7–1 **General.**

(a) Overriding royalty interests in geothermal leases constitute accountable acreage holdings under these regulations.

(b) If an overriding royalty interest is created which is not shown in the instrument of assignment or transfer, a statement must be filed in the proper BLM office describing the interest.

(c) Any such assignment will be deemed valid if accompanied by a statement over the assignee's signature that the assignee is a citizen of the United States, an association of such citizens, or a corporation organized under the laws of the United States or of one of the States or the District of Columbia, and that his interests in geothermal leases do not exceed the acreage limitations provided in these regulations.

(d) All assignments of overriding royalty interests must be filed for record in the proper BLM office within 90 days from the date of execution. Such interests will not receive formal approval.

§ 3241.7–2 **Limitation of overriding royalties.**

(a) Except as herein provided, an overriding royalty on the value of the output of all geothermal resources, or any of them, at the point of shipment to market may be created by assignment or otherwise: *Provided*, That, (1) the overriding royalty is not for less than one-fourth (1/4) of 1 percent of the value of such output; and does not exceed 50 percent of the rate of royalty due to the United States as specified in the geothermal lease, or as reduced pursuant to such lease, and (2) the overriding royalty, when added to overriding royalties previously created, does not exceed the maximum rate established herein.

(b) The creation of an overriding royalty interest that does not conform to the requirements of paragraph (a) of this section shall be deemed a violation of the lease terms, unless the agreement creating overriding royalties provides (1) for a prorated reduction of all overriding royalties so that the aggregate rate of royalties does not exceed the maximum rate established in paragraph (a) of this section and (2) for the suspension of an overriding royalty during any period when the royalties due to the United States have been suspended pursuant to the terms of the geothermal lease.

§ 3241.8 **Lease account status; requirements.**

Unless the lease account is in good financial standing as to the area covered by an assignment at the time the assignment and bond are filed, or is placed in good standing before the assignment is reached for action, the request for approval of the assignment will be denied, and the lease shall be subject to termination in accordance with these regulations.

§ 3241.9 **Effect of assignment.**

An assignment of the record title of the complete interest in a portion of the lands in a lease shall segregate the assigned and retained portions into separate and distinct leases. An assignment of an undivided interest in the entire leasehold shall not segregate the lease into separate or distinct leases.

Subpart 3242—Production and Use of Byproducts

§ 3242.1 **General.**

Where the Supervisor determines that production, use, or conversion of geothermal steam under a geothermal lease is susceptible of producing a valuable byproduct or byproducts, including commercially demineralized water contained in or derived from such geothermal steam for beneficial use in accordance with applicable State water laws, the authorized officer shall require substantial beneficial production or use thereof, except where he determines that:

(a) Beneficial production or use is not in the interest of conservation of natural resources;

(b) Beneficial production or use would not be economically feasible; or

(c) Beneficial production and use should not be required for other reasons satisfactory to him.

§ 3242.2 **Production and use of commercially demineralized water as a byproduct, production, and use of other sources of water.**

§ 3242.2–1 **General.**

Except as provided in these regulations, or the lease, the lessee shall have the right to process fluids, including brine, condensate, and other fluids, which are associated with geothermal steam within lands subject to the geothermal lease for the purpose of developing, producing, and utilizing the commercially demineralized water recovered as a result of such processing.

§ 3242.2–2 **Prohibition on production of commercially demineralized water.**

The lessee shall not be authorized to engage in the primary production of commercially demineralized water from the produced fluids contained in or derived from geothermal steam referred to in § 3243.3–1, where such use would result in the undue waste of geothermal energy.

§ 3242.2–3 **Water wells on geothermal areas.**

All leases issued under these regulations shall be subject to the condition that, where the lessee finds only potable water in any well drilled for production of geothermal resources, the Secretary may, when the water is of such quality and quantity as to be valuable and useable for agricultural, domestic, or other purpose, acquire the well with casing installed in the well at the fair market value of the casing.

§ 3242.2–4 **State water laws.**

Nothing in these regulations shall constitute an express or implied claim or

denial on the part of the Federal Government as to its exemption from State water laws.

Subpart 3243—Cooperative Conservation Provisions

§ 3243.1 Cooperative or unit plans.

For the purpose of more properly conserving the natural resources of any geothermal pool, field or like area, lessees and their representatives may unite with each other or jointly or separately with others, in collectively adopting and operating under a cooperative or unit plan of development or operation of any geothermal resource area, or any part thereof (whether or not any part of that geothermal resource area is then subject to any cooperative or unit plan of development or operation). Applications to unitize shall be filed with the Supervisor who shall certify whether such plan is necessary or advisable in the public interest. The procedure in obtaining approval of a cooperative or unit plan of development, the provisions for the supervision of the cooperative or unit plan, and a suggested text of an agreement, are contained in 30 CFR Part 271.

§ 3243.2 Acreage chargeability.

All leases committed to any unit or cooperative plan approved or prescribed by the Supervisor shall be excepted in determining holdings or control for purposes of acreage chargeability. For the extension of leases committed to a unit plan, see Subpart 3203 of this part.

§ 3243.3 Communitization or drilling agreements.

§ 3243.3–1 Approval.

(a) The Supervisor is authorized, when separate tracts under lease cannot be independently developed and operated in conformity with an established well-spacing or well-development program, to approve, or to require lessees to enter into, communitization or drilling agreements providing for the apportionment of production or royalties among the separate tracts of land comprising the drilling or spacing unit for the lease, or any portion thereof, with other lands, whether or not owned by the United States, when in the public interest. Operations or production pursuant to such an agreement shall be deemed to be operations or production as to each lease committed thereto.

(b) Preliminary requests to communitize separate tracts shall be filed in triplicate with the Supervisor.

(c) Executed agreements shall be submitted to the Supervisor in sufficient number to permit retention of five copies after approval.

§ 3243.3–2 Requirements.

The agreement shall describe the separate tracts comprising the drilling or spacing unit, disclose the apportionment of the production or royalties to the several parties and the name of the operator, and shall contain adequate provisions for the protection of the interests of all parties, including the United States. The agreement must be signed by or in behalf of all interested necessary parties and will be effective only after approval by the Supervisor.

§ 3243.4 Operating, drilling, development contracts or a combination for joint operations.

§ 3243.4–1 Approval.

(a) The Secretary may on such conditions as he may prescribe, approve operating, drilling, or development contracts made by one or more geothermal lessees, with one or more persons, associations, including partnerships, or corporation whenever he shall determine that such contracts are required for the conservation of natural resources or in the best interest of the United States.

(c) Contracts submitted for approval under this section should be filed with the Supervisor together with enough copies to permit retention of five copies after approval.

(d) The authority of the Secretary to approve operating, drilling, or development contracts without regard to acreage limitations ordinarily will be exercised only to permit operators to enter into contracts with a number of lessees sufficient to justify operations on a large scale for the discovery, development, production, or transmission, transportation, or utilization of geothermal resources, and to finance the same.

§ 3243.4–2 Requirements.

(a) The contract must be accompanied by a statement showing all the interests held by the contractor in the area or field and the proposed or agreed plan of operation or development of the field. All the contracts held by the same contractor in the area or field should be submitted for approval at the same time, and full disclosure of the project made. Complete details must be furnished in order that the Secretary may have facts upon which to make a definite determination in accordance herewith and to prescribe the conditions on which approval of the contracts shall be made.

(b) The application must show a reasonable need for the contract and that it will not result in any concentration of control over the production or sale of geothermal resources which would be inconsistent with the antimonopoly provisions of law.

§ 3243.4–3 Acreage chargeability.

All leases operated under approved operating, drilling or development contracts or-a-combination-for-joint-operations-and-interests-thereunder, shall be excepted in determining holdings or control for purposes of acreage chargeability.

Subpart 3244—Terminations and Expirations

§ 3244.1 Relinquishments.

(a) A lease, or any legal subdivision of the area covered by such lease, may be surrendered by the record title holder by filing a written relinquishment in triplicate in the proper BLM office, provided the partial relinquishment does not reduce the remaining acreage in the lease to less than 640 acres, except where a departure is occasioned by an irregular subdivision in which case the remaining leased acreage may be less than 640 acres by an amount which is smaller than the amount by which the area would be more than 640 acres if the irregular subdivision were added, and except that the minimum acreage provision of this section may be waived by the Secretary where he finds such exception is justified on the basis of exploratory and development data derived from activity on the leasehold. The relinquishment must: (1) describe the lands to be relinquished as described in the lease; (2) include a statement as to whether the relinquished lands had been disturbed and if so whether they were restored as prescribed by the terms of the lease; (3) state whether wells had been drilled on the lands and if so whether they had been placed in condition for abandonment; and (4) furnish a statement that all moneys due and payable to workmen employed on the leased premises have been paid.

(b) A relinquishment shall take effect on the date it is filed, subject to the continued obligation of the lessee and his surety: (1) To make payments of all accrued rentals and royalties; (2) to place all wells on the land to be relinquished in condition for suspension of operations or abandonment; (3) to restore the surface resources in accordance with all regulations and the terms of the lease; and (4) to comply with all other environmental stipulations provided for by such regulations or lease. A statement must be furnished that all moneys due and payable to workmen employed on the leased premises have been paid.

§ 3244.2 Automatic terminations and reinstatements.

§ 3244.2–1 General.

Except as provided in § 3245.2–2 any lease will automatically terminate by operation of law if the lessee fails to pay the rental on or before the anniversary date of such lease. However, if the time for payment falls upon any day in which the proper office to receive payment is not open, payment received on the next official working day shall be deemed to be timely. The termination of the lease for failure to pay the rental must be noted on the official records of the proper BLM office. Upon such notation the lands included in such lease will become subject to leasing as provided for in Subpart 3211 of this part.

§ 3244.2–2 Exceptions.

(a) *Nominal deficiency*. If the rental payment due under a lease is paid on or before its anniversary date but the amount of the payment is deficient and the deficiency is nominal, the lease shall not have automatically terminated unless the lessee fails to pay the deficiency within the period prescribed in a Notice of Deficiency, or by the due date, whichever is later. A deficiency is nominal if

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it is not more than $10 or one percentum (1%) of the total payment due, whichever is more. The authorized officer shall send a Notice of Deficiency to the lessee on an approved form. The Notice shall be sent by certified mail, return receipt requested, and shall allow the lessee 15 days from the date of receipt to submit the full balance due to the proper BLM office. If the payment called for in the notice is not made within the time allowed, the lease will have terminated by operation of law as of its anniversary date.

(b) *Reinstatements.* (1) Except as hereinafter provided, the authorized officer may reinstate a lease which has terminated automatically for failure to pay the full amount of rental due on or before the anniversary date, if it is shown to his satisfaction that such failure was either justifiable or not due to a lack of reasonable diligence on the part of the lessee; and a petition for reinstatement, together with the required rental, including any back rental which has accrued from the date of termination of the lease, is filed with the proper BLM office.

(2) The burden of showing that the failure to pay on or before the anniversary date was justifiable or not due to lack of reasonable diligence will be on the lessee. Reasonable diligence normally requires sending or delivering payments sufficiently in advance of the anniversary date to account for normal delays in the collection, transmittal, and delivery of the payment. The authorized officer may require evidence, such as post office receipts, of the time of sending or delivery of payments.

(3) Under no conditions will a lease be reinstated if (i) a valid lease has been issued prior to the filing of a petition for reinstatement affecting any of the lands covered by the terminated lease, or (ii) the interest in the lands has been withdrawn, disposed of, or has otherwise become unavailable for leasing. However, the authorized officer will not issue a new lease for lands covered by a lease which terminated automatically until 90 days after the date of termination.

(4) Reinstatement of terminated leases is discretionary with the Secretary. The basic criterion in accordance with which this discretion will be exercised is whether the Secretary would be willing to issue a lease if a new lease offer for the same land were under consideration.

§ 3244.3 Termination of lease for noncompliance with regulations or lease terms; notice; hearing.

A lease may be terminated by the authorized officer for any violation of these regulations, the regulations in 30 CFR Part 270, or the lease terms, 30 days after receipt by the lessee of notice from the authorized officer of the violation, unless (a) the violation has been corrected, or (b) the violation is one that cannot be corrected within the notice period and the lessee has in good faith commenced within the notice period to correct the violation and thereafter proceeds diligently to complete the correction. A lessee shall be entitled to a hearing on the matter of any such claimed violation or proposed termination of lease if a request for a hearing is made to the authorized officer within the 30-day period after notice. The procedures with respect to notice of such hearing and the conduct thereof, and with respect to appeals from decisions of hearing examiners upon such hearings, shall follow insofar as practicable the procedural rules applicable to hearings and appeals in public lands cases within the jurisdiction of the Board of Land Appeals, Office of Hearings and Appeals, contained in Department Hearings and Appeals Procedures, Part 4 of this title. The period for correction of violation or commencement to correct a violation of regulations or of lease terms, as aforesaid, shall be extended to 30 days after the lessee's receipt of the hearing examiner's decision upon such a hearing if the hearing examiner shall find that a violation exists.

§ 3244.4 Expiration by operation of law.

Any lease for land on which, or for which under an approved cooperative or unit plan of development or operation, there is no production in commercial quantities, or a producing well, or actual drilling operations being diligently prosecuted, will expire at the end of its primary term without notice to the lessee. Notation of such expiration need not be made on the official records, but the lands previously covered by that expired lease will be subject to the filing of new applications or nominations for leases only as provided in these regulations.

§ 3244.5 Removal of materials and supplies upon termination of lease.

Upon the expiration of the lease, or the earlier termination thereof pursuant to this subpart, the lessee shall have the privilege at any time within a period of ninety (90) days thereafter of removing from the premises any materials, tools, appliances, machinery, structures, and equipment other than improvements needed for producing wells. Any materials, tools, appliances, machinery, structures, and equipment subject to removal, but not removed within the 90-day period, or any extension thereof that may be granted because of adverse climatic conditions during that period, shall, at the option of the Supervisor, become property of the lessor, but the lessee shall remove any or all such property where so directed by the lessor.

Dated July 18, 1973.

WILLIAM W. LYON,
Deputy Under Secretary of the Interior.

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Geological Survey

[30 CFR Parts 270, 271]

GEOTHERMAL RESOURCES OPERATIONS ON PUBLIC, ACQUIRED AND WITHDRAWN LANDS AND GEOTHERMAL RESOURCES UNIT PLAN REGULATIONS (including suggested forms)

Notice of Proposed Rulemaking

The purpose of this revision in the proposed rulemaking for implementing the Geothermal Steam Act of December 24, 1970 (30 U.S.C. 1001–1025), is to provide the public with revisions planned as a result of the public hearings and comments received on the Draft Environmental Statement and previously published proposed rulemaking on operations and units (36 F.R. 13722, 8994, and 37 FR 25300). The Act provides for the leasing of public lands for the purpose of geothermal resource exploration, development and production. The changes in these regulations, since the last publication on November 29, 1972, are primarily administrative and procedural in nature and the environmental impact of these regulations is not believed to be significantly different from the impact of the regulations previously published.

It is the policy of the Department of the Interior, whenever practicable, to afford the public an opportunity to participate in the rulemaking process. Accordingly, interested parties may submit written comments, suggestions, or objections with respect to the proposed regulations to the Geothermal Coordinator, Department of the Interior, Washington, D.C. 20240, within 30 days of the date of publication of this notice in the FEDERAL REGISTER.

A Final Environmental Statement will be issued in accordance with the provisions of section 102(2)(C) of the National Environmental Policy Act of 1969 (42 U.S.C. 4332(2)(C)) prior to promulgation of any operating and unit regulations.

PART 270—GEOTHERMAL RESOURCES OPERATIONS ON PUBLIC, ACQUIRED, AND WITHDRAWN LANDS

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GENERAL PROVISIONS

§ 270.1 Purpose and authority.

The Geothermal Steam Act enacted on December 24, 1970 (84 Stat. 1566) referred to in this part as "the Act", authorizes the Secretary of the Interior to prescribe rules and regulations applicable to operations conducted under a lease granted pursuant to that Act, and for the development and conservation of geothermal steam and associated geothermal resources, the prevention of waste, the protection of the public interest, and the protection of water quality, and other environmental qualities. The regulations in this part shall be administered by the Director through the Chief, Conservation Division, or his duly appointed representative.

§ 270.2 Definitions.

As used in the regulations in this part, the term:

(a) "Secretary" means the Secretary of the Interior or any person duly authorized to exercise the powers vested in that officer.

(b) "Director" means the Director of the Geological Survey.

(c) "Supervisor" means a representative of the Secretary, subject to the direction and supervisory authority of the Director, the Chief, Conservation Division, Geological Survey, and the appropriate Regional Conservation Manager, Conservation Division, Geological Survey, authorized and empowered to regulate operations and to perform other duties prescribed in the regulations in this part or any subordinate of such a representative acting under his direction.

(d) "Geothermal lease" means a lease issued under 43 CFR Group 3200.

(e) "Lessee" means the individual, corporation, association, or municipality to which a geothermal lease has been issued and its successor in interest or assignee. It also means any agent of the lessee or an operator holding authority by or through the lessee.

(f) "Operator" means the individual, corporation, or association having control or management of operations on the leased lands or a portion thereof. The operator may be the lessee, designated operator, or agent of the lessee, or holder of rights under an approved operating agreement.

(g) "Geothermal resources" means (1) all products of geothermal processes, embracing indigenous steam, hot water, and hot brines; (2) steam and other gases, hot water, and hot brines, resulting from water, gas, or other fluids artificially introduced into geothermal formations; (3) heat or other associated energy found in geothermal formations; and (4) any byproduct derived therefrom.

(h) "Byproduct" means (1) any mineral or minerals (exclusive of oil, hydrocarbon gas, and helium), which are found in solution or developed in association with geothermal steam and which have a value of less than 75 per centum of the value of the geothermal steam or are not, because of quantity, quality, or technical difficulties in extraction and production, of sufficient value to warrant extraction and production by themselves, and (2) commercially demineralized water.

(i) "Participating area" means that part of the unit area which is deemed to be productive from a horizon or deposit and to which production would be allocated in the manner described in the unit agreement assuming that all lands are committed to the unit agreement.

(j) "Waste" means (1) physical waste, as that term is generally understood; (2) waste of reservoir energy through inefficiency, improper use of or unnecessary dissipation of reservoir energy; (3) the location, spacing, drilling, equipping, operating, or producing of any geothermal well or wells in a manner which causes or tends to cause reduction in the quantity of geothermal energy ultimately recoverable from a reservoir under prudent and workmanlike operations or which tends to cause unnecessary or excessive surface or subsurface loss or destruction of geothermal energy; and (4) the inefficient transmission of geothermal energy from the source (wellhead) to point of utilization.

(k) "Directionally drilled well" means the deviation of a well bore from the vertical or from its normal course in an intended predetermined direction or course with respect to the points of the compass. Directionally drilled well shall not include a well deviated for the purpose of straightening a hole that has become crooked in the normal course of drilling or holes deviated at random without regard to compass direction in an attempt to sidetrack a portion of the hole on account of mechanical difficulty in drilling.

(l) "Geothermal resources operational order" or "GRO order" means a formal numbered order, issued by the Supervisor, with the prior approval of the Chief, Conservation Division, Geological Survey, which implements the regulations in this part and applies to operations in an area, region, or any significant portion thereof.

(m) "Producible well" means a well which is capable of producing geothermal resources in commercial quantities.

(n) "Commercial quantities" means quantities sufficient to pay a profit after all costs of production have been met.

(o) "Area of operations" means that area of the leased lands which is required for exploration, development, and producing operations, and which is delineated on a map or plat which is made a part of the approved plan of operations. It encompasses the area generally needed for wells, flow lines, separators, surge tanks, drill pads, mud pits, workshops, and other such facilities used for on-project geothermal resources field exploration, development, and production operations.

JURISDICTION AND FUNCTIONS OF SUPERVISOR

§ 270.10 Jurisdiction.

Drilling and production operations, handling and measurement of production, determination and collection of royalty and, in general, all operations conducted on a geothermal lease are subject to the regulations in this part and the applicable regulations contained in 43 CFR Group 3200, and are under the jurisdiction of the Supervisor for the region in which the leased land is situated, subject to the supervisory authority of the Secretary and the Director.

§ 270.11 General functions.

The Supervisor is authorized and directed to carry out the provisions of this part. He will require compliance with the terms of geothermal leases, with the regulations in this part and the applicable regulations in 43 CFR Group 3200, and with the applicable statutes. He shall act on all applications, requests, and notices required in this part. In executing his functions under this part the Supervisor shall ensure that all operations, within the area of operations, will conform to the best practice and are conducted in such manner as

to protect the deposits of the leased lands and to result in the maximum ultimate recovery of geothermal resources, with minimum waste, and are consistent with the principles of the use of the land for other purposes and of the protection of the environment. Inasmuch as conditions in one area may vary widely from conditions in another area, the regulations in this part are intended to be general in nature. Detailed procedures hereunder in any particular area will be covered by GRO orders. The requirements to be set forth in GRO orders relating to surface resources or uses will be coordinated with the appropriate land management agency. The Supervisor may issue oral orders to govern lease operations, but such orders shall be confirmed in writing by the Supervisor as promptly as possible. The Supervisor may issue other orders and rules to govern the development and method for production of a deposit, field, or area. Prior to the issuance of GRO orders and other orders and rules and the approval of any plan of operations or any plan of development, the Supervisor shall, as appropriate, consult with, and receive comments from Federal and State agencies, lessees, operators, or interested parties. Before permitting other operations on the leased land, the Supervisor shall determine if the lease is in good standing, whether the lessee is authorized to conduct operations, has filed an acceptable bond, and has an approved plan of operations.

§ 270.12 **Regulation of operations.**

The Supervisor shall inspect and supervise operations performed under the regulations in this part to: (a) Prevent waste and damage to formations or deposits containing geothermal resources; (b) prevent unnecessary damage to other natural resources; (c) prevent degradation of the water quality; (d) protect air quality, water quality, and other environmental qualities; and (e) prevent injury to life or property. The Supervisor shall issue such GRO orders as are necessary to accomplish these purposes.

§ 270.13 **Required samples, tests, and surveys.**

When necessary or advisable, the Supervisor shall require that adequate samples be taken and tests or surveys be made using acceptable techniques, without cost to the lessor, to determine the identity and character of formations; the presence of geothermal resources, water, or reservoir energy; the quantity and quality of geothermal resources, water or reservoir energy; the amount and direction of deviation of any well from the vertical; formation, casing, and tubing pressures, temperatures, rate of heat and fluid flow, and whether operations are conducted in a manner looking to the protection of the interests of the lessor.

§ 270.14 **Drilling and abandonment of wells.**

The Supervisor shall require that drilling be conducted in accordance with the terms of the lease, GRO orders, and the regulations in this part and 43 CFR Group 3200; and shall require plugging and abandonment of any well or wells no longer necessary for operations in accordance with plans approved or prescribed by him. Upon the failure of a lessee to comply with any requirement under this section, the Supervisor is authorized to perform the work at the expense of the lessee and the surety.

§ 270.15 **Well spacing and well casing.**

The Supervisor shall approve proposed well-spacing and well-casing programs or prescribe such modifications to the programs as he determines necessary for proper development, giving consideration to such factors as: (a) Topographic characteristics of the area; (b) hydrologic, geologic and reservoir characteristics of the field; (c) the number of wells that can be economically drilled to provide the necessary volume of geothermal resources for the intended use; (d) protection of correlative rights; (e) minimizing well interference; (f) unreasonable interference with multiple use of lands; and (g) protection of the environment, including ground water quality.

§ 270.16 **Values and payment for losses.**

The Supervisor shall determine the value of production accruing to the lessor where there is loss through waste or failure to drill and produce protection wells on the lease, and the compensation due to the lessor as reimbursement for such loss. Payment for such losses will be paid when billed.

§ 270.17 **Suspension of operations and production.**

(a) On receipt of an application filed in accordance with 43 CFR 3205.3–8 for suspension of operations or production, or both, under a producing geothermal lease (or for relief from any drilling or producing requirements of such a lease), the Supervisor may, if he deems the suspension or relief warranted, approve the application.

(b) In the interest of conservation, the Supervisor may, on his own motion, suspend operations or production, or both, on any geothermal lease.

(c) Where operations or production, or both, under a lease, have been suspended, the Supervisor may approve resumption of operations or production either on his own motion or upon written request by the lessee or his agent.

(d) Whenever it appears from facts adduced by or furnished to the Supervisor that the interest of the lessor requires additional drilling or producing operations, he may, by written notice, order the beginning or resumption of such operations.

(e) Any action of the Supervisor under this Section shall be subject to the right of appeal under § 270.90.

(f) See 43 CFR 3205.3–7 and 3205.3–8 for regulations concerning requests to waive, suspend, or reduce payments of rental or royalty, and extensions of leases on which operations or production have been suspended.

REQUIREMENTS FOR LESSEES

(INCLUDING OPERATORS)

§ 270.30 **Lease terms, regulations, waste, damage, and safety.**

(a) The lessee shall comply with the lease terms, lease stipulations, applicable laws and regulations and any amendments thereof, GRO orders, and other written or oral orders of the Supervisor. All oral orders (to be confirmed in writing as provided in § 270.11) are effective when issued unless otherwise specified.

(b) The lessee shall take all reasonable precautions to prevent: (1) Waste; (2) damage to any natural resource including trees and other vegetation, fish and wildlife and their habitat; (3) injury or damage to persons, real or personal property; and (4) any environmental pollution or damage.

(c) Any significant effect on the environment created by the lessee's operations or failure to comply with environmental standards shall be reported to the Supervisor within 24 hours and confirmed in writing within 30 days.

§ 270.31 **Designation of operator or agent.**

In all cases where operations are not conducted by the lessee but are to be conducted under authority of an unapproved operating agreement, assignment or other arrangement, a "designation of operator" shall be submitted to the Supervisor, in a manner and form approved by him, prior to commencement of operations. Such a designation will be accepted as authority of the operator or his local representative to act for the lessee and to sign any papers or reports required under the regulations in this part. All changes of address and any termination of the authority of the operator shall be immediately reported, in writing, to the Supervisor.

§ 270.32 **Local agent.**

When required by the Supervisor, the lessee shall designate a local representative empowered to receive notices and comply with orders of the Supervisor issued pursuant to the regulations in this part.

§ 270.33 **Drilling and producing obligations.**

(a) The lessee shall diligently drill and produce such wells as are necessary to protect the lessor from loss by reason of production on other properties, or in lieu thereof, with the consent of the Supervisor, shall pay a sum determined by the Supervisor as adequate to compensate the lessor for failure to drill and produce any such well.

(b) The lessee shall promptly drill and produce such other wells as the Supervisor may require in order that the lease be developed and produced in accordance with good operating practices. (See 43 CFR 3204.5.)

§ 270.34 **Plan of operation.**

Prior to commencing any operations on the leased lands or on any lands covered by a unit or cooperative agreement, the lessee shall submit and obtain the approval of the Supervisor and the ap-

propriate land management agency of a plan of operation for the area. Such plan shall include:

(a) The proposed location of each well including a layout showing the position of the mud tanks, reserve pits, cooling towers, pipe racks, etc.;

(b) Existing and planned access and lateral roads;

(c) Location and source of water supply and road building material;

(d) Location of camp sites, air-strips, and other supporting facilities;

(e) Methods for disposing of waste material; and for protection of the environment;

(f) All pertinent information or data which the Supervisor may require to support the plan of operations for the utilization of geothermal resources and the protection of the environment.

(g) Provisions for monitoring deemed necessary by the Supervisor to ensure compliance with these regulations for the operations under the plan; and

(h) A requirement for the collection of data concerning the existing air and water quality, noise, seismic and land subsidence activities, and ecological system of the leased lands for at least one year prior to the submission of a plan for production.

§ 270.35 Subsequent well operations.

After completion of all operations authorized under any previously approved notice or plan, the lessee shall not begin to redrill, repair, deepen, plug back, shoot, or plug and abandon any well, make casing tests, alter the casing or liner, stimulate production, change the method of recovering production, or use any formation or well for brine or fluid injection until he has submitted to the Supervisor in writing a new plan of operations and has received written approval from him. However, in an emergency a lessee may take action to prevent damage without receiving prior approval from the Supervisor, but in such cases the lessee shall report his action to the Supervisor as soon as possible.

§ 270.36 Well designations.

The lessee shall mark each derrick upon commencement of drilling operations and each producing or suspended well in a conspicuous place with his name or the name of the operator, the serial number of the lease, the number and location of the well. Whenever possible, the well location shall be described by section or tract, township, range, and by quarter-quarter section or lot. The lessee shall take all necessary means and precautions to preserve these markings.

§ 270.37 Well records.

(a) The lessee shall keep for each well at his field headquarters or at other locations conveniently available to the Supervisor, accurate and complete records of all well operations including production, drilling, logging, directional well surveys, casing, perforation, safety devices, redrilling, deepening, repairing, cementing, alterations to casing, plugging, and abandoning. The records shall contain a description of any unusual malfunction, condition or problem; all the formations penetrated; the content and character of mineral deposits and water in each formation; thermal gradients, temperatures, pressures, analyses of geothermal waters, the kind, weight, size, grade, and setting depth of casing; and any other pertinent information.

(b) The lessee shall, within 30 days after completion of any well, transmit to the Supervisor copies of the records of all operations in a form prescribed by the Supervisor.

(c) Upon request of the Supervisor, the lessee will furnish (1) legible, exact copies of service company reports on cementing, perforating, acidizing, analyses of cores, electrical, and temperature logs, chemical analyses of steam and waters, or other similar services; (2) other reports and records of operations in the manner and form prescribed by the Supervisor.

§ 270.38 Samples, tests, and surveys.

(a) The lessee, when required by the Supervisor, will make adequate sampling, tests and/or surveys using acceptable techniques, to determine the presence, quantity, quality, and potential of geothermal resources, mineral deposits, or water; the amount and direction of deviation of any well from the vertical; and/or formation temperatures and pressures, casing, tubing, or other pressures and such other facts as the Supervisor may require. Such tests or surveys shall be made without cost to the lessor.

(b) The lessee shall, without cost to the lessor, take such formation samples or cores to determine the identity and character of any formation as are required and prescribed by the Supervisor.

§ 270.39 Directional survey.

The Supervisor may require an angular deviation and directional survey to be made of the finished hole of each directionally drilled well. The survey shall be made at the risk and expense of the lessee unless requested by an offset lessee, and then, at the risk and expense of the offset lessee. A copy of the survey shall be furnished the Supervisor.

§ 270.40 Well control.

The lessee or operator shall: (a) Take all necessary precautions to keep all wells under control at all times; (b) utilize trained and competent personnel; (c) utilize properly maintained equipment and materials; and (d) use operating practices which insure the safety of life and property. The selection of the types and weights of drilling fluids and provisions for controlling fluid temperatures, blowout preventers, and other surface control equipment and materials, casing and cementing programs, etc., to be used shall be based on sound engineering principles and shall take into account apparent geothermal gradients, depths and pressures of the various formations to be penetrated and other pertinent geologic and engineering data and information about the area.

§ 270.41 Pollution.

The lessee shall comply with all Federal and State standards with respect to the control of all forms of air, land, water, and noise pollution, including, but not limited to, the control of erosion and the disposal of liquid, solid, and gaseous wastes. The Supervisor may, in his discretion, establish additional and more stringent standards, and, if he does so, the lessee shall comply with those standards. Plans for disposal of well effluents must take into account effects on surface and subsurface waters, plants, fish and wildlife and their habitats, atmosphere, or any other effects which may cause or contribute to pollution, and such plans must be approved by the Supervisor before action is taken under them.

§ 270.42 Noise abatement.

The lessee shall minimize noise during exploration, development and production activities. Welfare of the operating personnel and the public must not be affected as a consequence of the noise created by the expanding gases. The method and degree of noise abatement shall be as approved by the Supervisor.

§ 270.43 Land subsidence and seismic activity.

In the event subsidence or seismic activity results from the production of geothermal resources, as determined by monitoring activities by the lessee or a government body, the lessee shall take such action as required by the lease or by the Supervisor.

§ 270.44 Pits and sumps.

The lessee shall provide and use pits and sumps of adequate capacity and design to retain all materials and fluids necessary to drilling, production, or other operations unless otherwise specified by the Supervisor. In no event shall the contents of a pit or sump be allowed to: (a) Contaminate streams, artificial canals or waterways, ground waters, lakes or rivers; (b) adversely affect environment, persons, plants, fish and wildlife and their habitats; or (c) damage the aesthetic values of the property or adjacent properties. When no longer needed, pits and sumps are to be filled and covered and the premises restored to a near natural state, as prescribed by the Supervisor.

§ 270.45 Well abandonment.

The lessee shall promptly plug and abandon any well on the leased land that is not used or useful. No well shall be abandoned until its lack of capacity for further profitable production of geothermal resources has been demonstrated to the satisfaction of the Supervisor. Before abandoning a producible well, the lessee shall submit to the Supervisor a statement of reasons for abandonment and his detailed plans for carrying on the necessary work. The detailed plans shall provide for the preservation of fresh water aquifers and for the prevention of intrusion into such aquifers

of saline or polluted waters. A producible well may be abandoned only after receipt of written approval by the Supervisor. No well shall be plugged and abandoned until the manner and method of plugging have been approved or prescribed by the Supervisor. Equipment shall be removed, and premises at the well site shall be restored as near as reasonably possible to its original condition immediately after plugging operations are completed on any well except as otherwise authorized by the Supervisor. Drilling equipment shall not be removed from any suspended drilling well without taking adequate measures to close the well and protect the subsurface resources.

§ 270.46 **Accidents.**

The lessee shall take all reasonable precautions to prevent accidents and shall notify the Supervisor within 24 hours of all accidents on the leased land, and shall submit a full report thereon within 15 days.

§ 270.47 **Workmanlike operations.**

The lessee shall carry on all operations and maintain the property at all times in a workmanlike manner, having due regard for the conservation of the property and the environment and for the health and safety of employees. The lessee shall remove from the property or store, in an orderly manner, all scrap or other materials not in use.

§ 270.48 **Departure from orders.**

The Supervisor may prescribe or approve either in writing or orally, with prompt written confirmation, variances from the requirements of GRO orders and other orders issued pursuant to these regulations, when such variances are necessary for the proper control of a well, conservation of natural resources, protection of human health and safety, property, or the environment. The Supervisor shall inform other Federal and State agencies, as appropriate, of any action taken under this section.

§ 270.49 **Sales contracts.**

The lessee shall file with the Supervisor within 30 days after the effective date of the sales contract a copy of any contract for the disposal of geothermal resources from the lease.

§ 270.50 **Royalty payments.**

The lessee shall pay all royalties as due under the terms of the lease. Payments of royalties are due not later than the last day of the month following the month in which the resource is sold or utilized, and shall be by check, bank draft, or money order, drawn to the order of the United States Geological Survey.

MEASUREMENT OF PRODUCTION AND COMPUTATION OF ROYALTIES

§ 270.60 **Measurement of geothermal resources.**

The lessee shall measure or gauge all production in accordance with methods approved by the Supervisor. The quantity and quality of all production shall be determined in accordance with the standard practices, procedures, and specifications generally used in industry. All measuring equipment shall be tested periodically and, if found defective, the Supervisor will determine the quantity and quality of production from the best evidence available.

§ 270.61 **Determination of content of byproducts.**

The lessee shall periodically furnish the Supervisor the results of periodic tests showing the content of byproducts in the produced geothermal fluid and gases. Such tests shall be taken as specified by the Supervisor and by the method of testing approved by him.

§ 270.62 **Value of geothermal production for computing royalties.**

(a) The value of geothermal production from the leased premises for the purpose of computing royalties shall be the reasonable value of the energy and the byproducts attributable to the lease as determined by the Supervisor. In determining the reasonable value of the energy and the byproducts the Supervisor shall consider:

(1) The highest price paid for a majority of the production of like quality in the same field or area;

(2) The total consideration accruing to the lessee from any disposition of the geothermal production;

(3) The value of the geothermal production used by the lessee;

(4) The value and cost of alternate available energy sources and byproducts;

(5) The cost of exploration and production, exclusive of taxes;

(6) The economic value of the resource in terms of its ultimate utilization;

(7) Production agreements between producer and purchaser; and

(8) Any other matters which he may consider relevant.

(b) Under no circumstances shall the value of any geothermal production for the purposes of computing royalties be less than:

(1) The total consideration accruing to the lessee from the sale thereof in cases where geothermal resources are sold by the lessee to another party;

(2) That amount which is the value of the end product attributable to the geothermal resource produced from a particular lease where geothermal resources are not sold by the lessee before being utilized, but are instead directly used in manufacturing, power production, or other industrial activity; or

(3) When a part of the resource only is utilized by the lessee and the remainder sold, the sum of the value of the end product attributable to the geothermal resource and the sales price received for the geothermal resources

§ 270.63 **Computation of royalties.**

(a) The value of geothermal production from a particular lease as determined pursuant to § 270.62 hereof, shall be apportioned between geothermal steam, heat, and other forms of energy and the byproducts.

(b) The royalties payable shall be the sum of (1) the amount resulting from the multiplication of the value attributable to the geothermal steam, heat, and other forms of energy by the royalty rate set for such forms of geothermal energy in the lease and (2) the amount resulting from the multiplication of the value attributable to byproducts by the royalty rate for byproducts set in the lease.

§ 270.64 **Commingling production.**

The supervisor may authorize a lessee to commingle production from wells on his lease with production from other leases held by him or by other lessees subjects to such conditions as he may prescribe.

REPORTS TO BE MADE BY ALL LESSEES (INCLUDING OPERATORS)

§ 270.70 **General requirements.**

Information required to be submitted in accordance with the regulations in this part shall be furnished as directed by the Supervisor. Copies of forms can be obtained from the Supervisor and must be filed with that official within the time limit prescribed.

§ 270.71 **Application for permit to drill, redrill, deepen, or plug-back.**

(a) A permit to drill, redrill, deepen, or plug-back a well on Federal lands must be obtained from the Supervisor before the work is begun. The application for the permit, which shall be filed in triplicate with the Supervisor, shall state the location of the well in feet, and direction from the nearest section or tract lines as shown on the official plat of survey or protracted surveys; the altitude of the ground and derrick floor above sea level and how it was determined, and should be accompanied by a proposed plan of operations as required by these regulations.

(b) The proposed drilling and casing plan shall be outlined in detail under the heading "Details of Work" in the applications referred to herein, and shall describe the type of tools and equipment to be used, the proposed depth to which the well will be drilled, the estimated depths to the top of important markers, the estimated depths at which water, geothermal resources, or other mineral resources are expected, the proposed casing program (including the size and weight of casing), the depth at which each string is to be set, and the amount of cement and mud to be used, the drilling method and type of circulating media (water, mud, foam, air or combinations thereof), the type of blowout prevention equipment to be used, the proposed coring, logging, or other program (such as drilling time log and sample description) to be used to determine the formations penetrated and the proposed program for determining geothermal gradients and the sampling and analysis of geothermal resources.

(c) Each application shall be accompanied by a plat showing the surface and expected bottomhole locations and

the distances from the nearest section or tract lines as shown on the official plat of survey or protracted surveys. The scale shall not be less than 2,000 feet to 1 inch.

(d) Each application should be accompanied by supporting structural and hydrologic information based on available geologic and geophysical data.

§ 270.72 Sundry notices and reports on wells.

(a) Any written notice of intention to do work or to change plans previously approved must be filed with the Supervisor in triplicate, unless otherwise directed, and must be approved by him before the work is begun. If, in case of emergency, any notice is given orally or by wire, and approval is obtained, the transaction shall be confirmed in writing. A subsequent report of the work performed must also be filed with the Supervisor.

(b) Casing test: Notice shall be given in advance to the Supervisor or his representative of the date and time when the operator expects to make a casing test. Later, by agreement, the exact time shall be fixed. In the event of casing failure during the test, the casing must be repaired or replaced or recemented as required by the Supervisor or his representative. The results of the test must be reported within 30 days after making a casing test. The report must describe the test completely and state the amount of mud and cement used, the lapse of time between running and cementing the casing and making the test, and the method of testing.

(c) Repairs or conditioning of well: Before the repairing or conditioning of a well, a notice setting forth in detail the plan of work must be filed with, and approved by, the Supervisor. A detailed report of the work accomplished and the methods employed, including all dates, and the results of such work must be filed within 30 days after completion of the repair work.

(d) Well stimulation: Before the lessee commences stimulation of a well by any means, a notice, setting forth in detail the plan of work, must be filed with and approved by the Supervisor. The notice shall name the type of stimulant and the amount to be used. A report showing the amount of stimulant used and the production rate before and after stimulation must be filed within 30 days from completion of the work.

(e) Altering casing in a well: Notice of intention to run a liner or to alter the casing by pulling or perforating by any means must be filed with and approved by the Supervisor before the work is started. This notice shall set forth in detail the plan of work. A report must be filed within 30 days after completion of the work stating exactly what was done and the results obtained.

(f) Notice of intention to abandon well: Before abandonment work is begun on any well, whether a drilling well, geothermal resources well, water well, or so-called dry hole, notice of intention to abandon shall be filed with, and approved by, the Supervisor. The notice must be accompanied by a complete log, in duplicate, of the well to date, provided the complete log has not been filed previously, and must give a detailed statement of the proposed work, including such information as kind, location, and length of plugs (by depths), plans for mudding, cementing, shooting, testing, and removing casing, and any other pertinent information.

(g) Subsequent report of abandonment: After a well is abandoned or plugged, a subsequent record of work done must be filed with the Supervisor. This report shall be filed separately within 30 days after the work is done. The report shall give a detailed account of the manner in which the abandonment or plugging work was carried out, including the nature and quantities of materials used in plugging and the location and extent (by depths) of the plugs of different materials; records of any tests or measurements made, and of the amount, size, and location (by depths) of casing left in the well; and a detailed statement of the volume of mud fluid used, and the pressure attained in mudding. If an attempt was made to part any casing, a complete report of the methods used and results obtained must be included.

§ 270.73 Log and history of well.

The lessee shall furnish in duplicate to the Supervisor, not later than 30 days after the completion of each well, a complete and accurate log and history, in chronological order, of all operations conducted on the well. A log shall be compiled for geologic information from cores or formations samples and duplicate copies of such log shall be filed. Duplicate copies of all electric logs, temperature surveys, water and steam analyses, hydrologic or heat flow tests, or direction surveys, if run, shall be furnished.

§ 270.74 Monthly report of operations.

A report of operations for each lease must be made for each calendar month, beginning with the month in which drilling operations are initiated. The report must be filed in duplicate with the Supervisor on or before the last day of the month following the month for which the report is filed unless an extension of time for the filing of the report is granted by the Supervisor. The report shall disclose accurately all operations conducted on each well during the month, the status of operations on the last day of the month, and a general summary of the status of operations on the leased lands. The report must be submitted each month until the lease is terminated or until omission of the report is authorized by the Supervisor. The report shall show for each calendar month:

(a) The lease serial number or the unit or communitization agreement number which shall be inserted in the upper right corner;

(b) Each well listed separately by number, and its location by 40-acre subdivision (quarter-quarter section or lot), section number, township, range, and meridian;

(c) The number of days each well was produced, whether steam or hot water or both were produced, and the number of days each input well was in operation, if any;

(d) The quantity of production and any byproducts obtained from each well, if any are recovered;

(e) The depth of each active or suspended well, and the name, character, and depth of each formation drilled during the month, the date and reason for every shutdown, the names and depths of important formation changes, the amount and size of any casing run since the last report, the dates and results of any tests or environmental monitoring conducted, and any other noteworthy information on operations not specifically provided for in the form.

(f) The footnote must be completely filled out as required by the Supervisor. If no sales were made during the calendar month, the report must so state.

§ 270.75 Monthly report of sales and royalty.

A report of sales and royalty for each productive lease must be filed each month once sales of production are made even though sales may be intermittent, unless otherwise authorized by the Supervisor. Total volumes of geothermal resources produced and sold, the value of production, and the royalty due the lessor must be shown. If byproducts are being recovered, the same requirement shall be applicable. This report is due on or before the last day of the month following the month in which production was obtained and sold or utilized, together with the royalties due the United States. Payment or royalty is to be made pursuant to § 270.50 unless otherwise authorized by the Supervisor.

§ 270.76 Annual report of compliance with environmental protection requirements.

The lessee shall submit annually a report giving a full account of the actions taken to comply with the appropriate Federal and State regulations or requirements of the Supervisor pertaining to the protection of the surface and subsurface environment. This report shall include but is not limited to such matters as:

(a) Noise abatement;
(b) Water quality;
(c) Air quality;
(d) Erosion control;
(e) Subsidence and seismic activity;
(f) Rehabilitation activities;
(g) Waste disposal; and
(h) Environmental effects on flora and fauna.

§ 270.77 Annual report of expenditures for diligent exploration operations.

A report of expenditures for exploration operations conducted during a lease year must be submitted annually to the Supervisor in order that such expenditures may be considered for qualification as diligent exploration pursuant to 43 CFR 3203.5.

§ 270.78 Forms or reports.

When forms or reports other than those referred to in the regulations in this part may be necessary, instructions for the filing of such forms or reports will be given by the Supervisor.

§ 270.79 Public inspection of records.

Geologic and geophysical interpretations, maps, and data required to be submitted under this part shall not be available for public inspection without the consent of the lessee so long as the lease remains in effect.

PROCEDURE IN CASE OF VIOLATION OF THE REGULATIONS OR LEASE TERMS

§ 270.80 Noncompliance with regulations or lease terms.

Whenever a lessee or anyone acting under his authority fails to comply with the provisions of the regulations or lease terms, the Supervisor shall give the lessee notice to remedy any defaults or violations. The Supervisor is authorized to shut down any operations which he determines are unsafe or are causing or can cause pollution. Failure by the lessee to perform or commence the necessary remedial action pursuant to the notice will result in a shut down of operations and may result in referral of the matter to the authorized officer of the Bureau of Land Management for action pursuant to 43 CFR 3245.3.

APPEALS

§ 270.90 Appeals.

(a) Any party to a case adversely affected by a final order or decision of an officer of the Conservation Division of the Geological Survey shall have a right to appeal to the Director, unless the order or decision was approved by the Secretary or the Director prior to promulgation.

(b) An appeal to the Director may be taken by filing a notice of appeal in the office of the official who issued the order or decision within 30 days from service of the order or decision. The notice of appeal shall incorporate, or be accompanied by, such written showing and argument on the facts and the law as the appellant may deem adequate to justify reversal or modification of the order or decision. Within the same 30-day period, the appellant will be permitted to file in the office of the officer who issued the order or decision additional statements of reasons and written arguments or briefs. The officer with whom the appeal is filed shall transmit the appeal and accompanying papers to the Director with a full report and his recommendation on the appeal. The Director will review the record and render a decision in the case.

(c) Oral argument in any case pending before the Director will be allowed on motion in the discretion of such officer and at a time to be fixed by him.

(d) With the exception of the time fixed for filing a notice of appeal, the time for filing any document in connection with an appeal may be extended by the Director. A request for an extension of time must be filed within the time allowed for filing of the document and must be filed in the same office in which the document in connection with which the extension is requested must be filed.

(e) Any party to a case adversely affected by a decision of the Director under this part shall have a right of appeal to the Board of Land Appeals in the Office of Hearings and Appeals, Office of the Secretary, in accordance with the procedures provided in 43 CFR Part 4, Department Hearings and Appeals Procedures.

PART 271—GEOTHERMAL RESOURCES UNIT PLAN REGULATIONS (INCLUDING SUGGESTED FORMS)

GENERAL PROVISIONS

AUTHORITY: The provisions of this Part 271 issued under section 18 of the Geothermal Steam Act of 1970 (84 Stat. 1566) (see 43 CFR Subpart 3244).

§ 271.1 Introduction.

The regulations in this part prescribe the procedure to be followed and the requirements to be met by holders of Federal geothermal leases (see § 271.2d) and their representatives who wish to unite with each other, or jointly or separately with others, in collectively adopting and operating under a cooperative or unit plan for the development of any geothermal resources pool, field, or like area, or any part thereof. Such agreements may be initiated by lessees, or where in the interest of conserving natural resources they are deemed necessary they may be required by the Director.

§ 271.2 Definitions.

The following terms, as used in this part or in any agreement approved under the regulations in this part, shall have the meanings here indicated unless otherwise defined in such agreement:

(a) *Unit agreement.* An agreement or plan of development and operation for the production and utilization of separately owned interests in the geothermal resources made subject thereto as a single consolidated unit without regard to separate ownerships and which provides for the allocation of costs and benefits on a basis defined in the agreement or plan.

(b) *Cooperative agreement.* An agreement or plan of development and operations for the production and utilization of geothermal resources made subject thereto in which separate ownership units are independently operated without allocation of production.

(c) *Agreement.* For convenience, the term "agreement" as used in the regulations in this part refers to either a unit or a cooperative agreement as defined in paragraphs (a) and (b) of this section unless otherwise indicated.

(d *Geothermal lease.* A lease issued under the act of December 24, 1970 (84 Stat. 1566), pursuant to the leasing regulations contained in 43 CFR Part 3200, and, unless the context indicates otherwise, "lease" means a geothermal lease.

(e) *Unit area.* The area described in a unit agreement as constituting the land logically subject to development under such agreement.

(f) *Unitized land.* The part of a unit area committed to a unit agreement.

(g) *Unitized substances.* Deposits of geothermal resources recovered from unitized land by operation under and pursuant to a unit agreement.

(h) *Unit operator.* The person, association, partnership, corporation, or other business entity designated under a unit agreement to conduct operations on unitized land as specified in such agreement.

(i) *Participating area.* That part of the Unit Area which is deemed to be productive from a horizon or deposit and to which production would be allocated in the manner described in the unit agreement assuming that all lands are committed to the unit agreement.

(j) *Working interest.* The interest held in geothermal resources or in lands containing the same by virtue of a lease, operating agreement, fee title, or otherwise, under which, except as otherwise provided in a unit or cooperative agreement, the owner of such interest is vested with the right to explore for, develop, produce, and utilize such resources. The right delegated to the unit operator as such by the unit agreement is not to be regarded as a working interest.

(k) *Secretary.* The Secretary of the Interior or any person duly authorized to exercise powers vested in that officer.

(l) *Director.* The Director of the U.S. Geological Survey.

(m) *Supervisor.* A representative of the Secretary, subject to the direction and supervisory authority of the Director, the Chief, Conservation Division, Geological Survey, and the appropriate Regional Conservation Manager, Conservation Division, Geological Survey, authorized and empowered to regulate operations and to perform other duties prescribed in the regulations in this part or any subordinate of such representative acting under his direction.

§ 271.3 Designation of area.

An application for designation of an area as logically subject to development

and/or operation under a unit or cooperative agreement may be filed, in triplicate, by any proponent of such an agreement through the Supervisor. Each copy of the application shall be accompanied by a map or diagram on a scale of not less than 1 inch to 1 mile, outlining the area sought to be designated under this section. The Federal, State, and privately owned land should be indicated on said map by distinctive symbols or colors and Federal geothermal leases and lease applications should be identified by serial number. Geological information, including the results of geophysical surveys, and such other information as may tend to show that unitization is necessary and advisable in the public interest should be furnished in triplicate. Geological and geophysical information and data so furnished will not be available for public inspection, as provided by 5 U.S.C. section 552(b), without the consent of the proponent. The application and supporting data will be considered by the Director and the applicant will be informed of the decision reached. The designation of an area, pursuant to an application filed under this section, shall not create an exclusive right to submit an executed agreement for such area, nor preclude the inclusion of such area or any part thereof in another unit area.

§ 271.4 Preliminary consideration of agreements.

The form of unit agreement set forth in § 271.12 is acceptable for use in unproved areas. The use of this form is not mandatory, but any proposed departure therefrom should be submitted with the application submitted under § 271.3 for preliminary consideration and for such revision as may be deemed necessary. In areas proposed for unitization in which a discovery of geothermal resources has been made, or where a cooperative agreement is contemplated, the proposed agreement should be submitted with the application submitted under § 271.3 for preliminary consideration and for such revision as may be deemed necessary. The proposed form of agreement should be submitted in triplicate and should be plainly marked to identify the proposed variances from the form of agreement set forth in § 271.12.

§ 271.5 State land.

Where State-owned land is to be included in the unit, approval of the agreement by appropriate State officials should be obtained prior to its submission to the Department for approval of the executed agreement. When authorized by the laws of the State in which the unitized land is situated, provisions may be made in the agreement accepting State law, to the extent that they are applicable to non-Federal unitized land.

§ 271.6 Qualifications of unit operator.

A unit operator must qualify as to citizenship in the same manner as those holding interests in geothermal leases issued under the Geothermal Steam Act of 1970. The unit operator may be an owner of a working interest in the unit area or such other party as may be selected by the owners of working interests and approved by the Supervisor. The unit operator shall execute an acceptance of the duties and obligations imposed by the agreement. No designation of, or change in, a unit operator will become effective unless and until approved by the Supervisor, and no such approval will be granted unless the unit operator is deemed qualified to fulfill the duties and obligations prescribed in the agreement.

§ 271.7 Parties to unit or cooperative agreement.

The owners of any rights, title, or interest in the geothermal resources deposits to be developed and operated under an agreement can be regarded as proper parties to a proposed agreement. All such owners must be invited to join as parties to the agreement. If any owner fails or refuses to join the agreement, the proponent of the agreement should declare this to the Supervisor and should submit evidence of efforts made to obtain joinder of such owner and the reasons for nonjoinder.

§ 271.8 Approval of an executed unit or cooperative agreement.

(a) A duly executed unit or cooperative agreement will be approved by the Secretary, or his duly authorized representative, upon a determination that such agreement is necessary or advisable in the public interest and is for the purpose of properly conserving the natural resources. Taking into account the environmental consequences of the action. Such approval will be incorporated in a certificate appended to the agreement. No such agreement will be approved unless at least one of the parties is a holder of a Federal lease embracing lands being committed to the agreement and unless the parties signatory to the agreement hold sufficient interests in the area to give effective control of operations therein.

(b) Where a duly executed agreement is submitted for Departmental approval, a minimum of six signed counterparts should be filed. The same number of counterparts should be filed for documents supplementing, modifying, or amending an agreement, including change of operator, designation of new operator, and notice of surrender, relinquishment, or termination.

(c) The address of each signatory party to the agreement should be inserted below the party's signature. Each signature should be attested by at least one witness, if not notarized. Corporate or other signatures made in a representative capacity must be accompanied by evidence of the authority of the signatories to act unless such evidence is already a matter of record in the United States Geological Survey. (The parties may execute any number of counterparts of the agreement with the same force and effect as if all parties signed the same document, or may execute a ratification or consent in a separate instrument with like force and effect.).

(d) Any modification of an approved agreement will require approval of the Secretary or his duly authorized representative under procedures similar to those cited in paragraph (a) of this section.

§ 271.9 Filing of papers and number of counterparts.

(a) All proposals and supporting papers, instruments, and documents submitted under this part should be filed with the Supervisor, unless otherwise provided in this part or otherwise instructed by the Director.

(b) Plans of development and operation, plans of further development and operation, and proposed participating areas and revisions thereof should be submitted in quadruplicate.

(c) Each application for approval of a participating area, or revision thereof, should be accompanied by three copies of a substantiating geologic and engineering report, structure contour map or maps, cross-section or other pertinent data.

(d) Other instruments or documents submitted for approval should be submitted for approval in sufficient number to permit the approving official to return at least one approved counterpart.

§ 271.10 Bonds.

In lieu of separate bonds required for each Federal lease committed to a unit agreement, the unit operator may furnish and maintain a collective corporate surety bond or a personal bond conditioned upon faithful performance of the duties and obligations of the agreement and the terms of the leases subject thereto. Personal bonds shall be accompanied by a deposit of negotiable Federal securities in a sum equal at their par value to the amount of the bond and by a proper conveyance to the Secretary of full authority to sell such securities in case of default in the performance of the obligations assumed. The liability under the bond shall be for such amount as the Supervisor shall determine to be adequate to protect the interests of the United States. Additional bond coverage may be required whenever deemed necessary by the Supervisor. The bond must be filed with and accepted by the Bureau of Land Management before operations will be approved. A form of corporate surety bond is set forth in § 271.15. In case of changes of unit operator, a new bond must be filed or a consent of surety to the change in principal under the existing bond must be furnished.

§ 271.11 Appeals.

Appeals may be taken in the manner provided in § 270.90 of this chapter from any decision or order issued under the regulations in this part, unless such decision or order was approved by the Secretary prior to promulgation.

§ 271.12 Form of unit agreement for unproved areas.

UNIT AGREEMENT FOR THE DEVELOPMENT AND OPERATION OF THE ---------- UNIT AREA
COUNTY OF ----------------------------
STATE OF ----------------------------

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------------------------ UNIT AGREEMENT
--------------- COUNTY ---------------

This Agreement entered into as of the ------ day of ------------, 19--, by and between the parties subscribing, ratifying, or consenting hereto, and herein referred to as the "parties hereto".

WITNESSETH: Whereas the parties hereto are the owners of working, royalty, or other geothermal resources interests in land subject to this Agreement; and

Whereas the Geothermal Steam Act of 1970 (84 Stat. 1566), hereinafter referred to as the "Act", authorizes Federal lessees and their representatives to unite with each other, or jointly or separately with others, in collectively adopting and operating under a cooperative or unit plan of development or operation of any geothermal resources pool, field, or like area, or any part thereof, for the purpose of more properly conserving the natural resources thereof, whenever determined and certified by the Secretary of the Interior to be necessary or advisable in the public interest; and

Whereas the parties hereto hold sufficient interest in the ---------- Unit Area covering the land herein described to effectively control operations therein; and

Whereas, it is the purpose of the parties hereto to conserve natural resources, prevent waste, and secure other benefits obtainable through development and operations of the area subject to this Agreement under the terms, conditions, and limitations herein set forth;

Now, therefore, in consideration of the premises and the promises herein contained, the parties hereto commit to this agreement their respective interests in the below-defined Unit Area, and agree severally among themselves as follows:

ARTICLE I—ENABLING ACT AND REGULATIONS

1.1 The Act and all valid pertinent regulations, including operating and unit plan regulations, heretofore or hereafter issued thereunder are accepted and made a part of this agreement as to Federal lands.

1.2 As to non-Federal lands, the geothermal resources operating regulations in effect as of the effective date hereof governing drilling and producing operations, not inconsistent with the laws of the State in which the non-Federal land is located, are hereby accepted and made a part of this agreement.

ARTICLE II—DEFINITIONS

2.1 The following terms shall have the meanings here indicated:

(a) *Geothermal lease.* A lease issued under the act of December 24, 1970 (84 Stat. 1566), pursuant to the leasing regulations contained in 43 CFR Group 3200 and, unless the context indicates otherwise, "lease" shall mean a geothermal lease.

(b) *Unit area.* The area described in Article III of this Agreement.

(c) *Unit Operator.* The person, association, partnership, corporation, or other business entity designated under this Agreement to conduct operations on Unitized Land as specified herein.

(d) *Participating area.* That part of the Unit Area which is deemed to be productive from a horizon or deposit and to which production would be allocated in the manner described in the unit agreement assuming that all lands are committed to the unit agreement.

(e) *Working interest.* The interest held in geothermal resources or in lands containing the same by virtue of a lease, operating agreement, fee title, or otherwise, under which, except as otherwise provided in this Agreement, the owner of such interest is vested with the right to explore for, develop, produce and utilize such resources. The right delegated to the Unit Operator as such by this Agreement is not to be regarded as a Working Interest.

(f) *Secretary.* The Secretary of the Interior or any person duly authorized to exercise powers vested in that officer.

(g) *Director.* The Director of the U.S. Geological Survey.

(h) *Supervisor.* A representative of the Secretary, subject to the direction and supervisory authority of the Director, the Chief, Conservation Division, Geological Survey, and the appropriate Regional Conservation Manager, Conservation Division, Geological Survey, authorized and empowered to regulate operations and to perform other duties prescribed in the regulations in this part or any subordinate of such representative acting under his direction.

ARTICLE III—UNIT AREA AND EXHIBITS

3.1 The area specified on the map attached hereto marked "Exhibit A" is hereby designated and recognized as constituting the Unit Area, containing ---------- acres, more or less.

The above-described Unit Area shall when practicable be expanded to include therein any additional lands or shall be contracted to exclude lands whenever such expansion or contraction is deemed to be necessary or advisable to conform with the purposes of this Agreement.

3.2 Exhibit A attached hereto and made a part hereof is a map showing the boundary of the Unit Area, the boundaries and identity of tracts and leases in said area to the extent known to the Unit Operator.

3.3 Exhibit B attached hereto and made a part hereof is a schedule showing to the extent known to the Unit Operator the acreage, percentage, and kind of ownership of geothermal resources interests in all lands in the Unit Area.

3.4 Exhibits A and B shall be revised by the Unit Operator whenever changes in the Unit Area render such revision necessary, or when requested by the Supervisor, and not less than five copies of the revised Exhibits shall be filed with the Supervisor.

ARTICLE IV—CONTRACTION AND EXPANSION OF UNIT AREA

4.1 Unless otherwise specified herein, the expansion and/or contraction of the Unit Area contemplated in Article 3.1 hereof shall be effected in the following manner:

(a) Unit Operator either on demand of the Director or on its own motion and after prior concurrence by the Director, shall prepare a notice of proposed expansion or contraction describing the contemplated changes in the boundaries of the Unit Area, the reasons therefore, and the proposed effective date thereof, preferably the first day of a month subsequent to the date of notice.

(b) Said notice shall be delivered to the Supervisor, and copies thereof mailed to the last known address of each Working Interest Owner, Lessee, and Lessor whose interests are affected, advising that 30 days will be allowed for submission to the Unit Operator of any objections.

(c) Upon expiration of the 30-day period provided in the preceding item (b) hereof, Unit Operator shall file with the Supervisor evidence of mailing of the notice of expansion or contraction and a copy of any objections thereto which have been filed with the Unit Operator, together with an application in sufficient number, for approval of such expansion or contraction and with appropriate joinders.

(d) After due consideration of all pertinent information, the expansion or contraction shall, upon approval by the Supervisor, become effective as of the date prescribed in the notice thereof.

4.2 Unitized Leases, insofar as they cover any lands which are excluded from the Unit Area under any of the provisions of this Article IV may be maintained and continued in force and effect in accordance with the terms, provisions, and conditions contained in the Act, and the lease or leases and amendments thereto, except that operations and/or production under this Unit Agreement shall not serve to maintain or continue the excluded portion of any lease.

4.3 All legal subdivisions of unitized lands (i.e., 40 acres by Governmental survey or its nearest lot or tract equivalent in instances of irregular surveys), no part of which is entitled to be within a Participating Area on the fifth anniversary of the effective date of the initial Participating Area established under this Agreement, shall be eliminated automatically from this Agreement effective as of said fifth anniversary and such lands shall no longer be a part of the Unit Area and shall no longer be subject to this Agreement unless diligent drilling operations are in progress on an exploratory well on said fifth anniversary, in which event such lands shall not be eliminated from the Unit Area for as long as exploratory drilling operations are continued diligently with not more than four (4) months time elapsing between the completion of one exploratory well and the commencement of the next exploratory well.

4.4 An exploratory well, for the purposes of this Article IV is defined as any well, regardless of surface location, projected for com-

pletion in a zone or deposit below any zone or deposit for which a Participating Area has been established and is in effect, or any well, regardless of surface location, projected for completion at a subsurface location under Unitized Lands not entitled to be within a Participating Area.

4.5 In the event an exploratory well is completed during the four (4) months immediately preceding the fifth anniversary of the initial Participating Area established under this Agreement, lands not entitled to be within a Participating Area shall not be eliminated from this Agreement on said fifth anniversary, provided the drilling of another exploratory well is commenced under an approved Plan of Operation within four (4) months after the completion of said well. In such event, the land not entitled to be in participation shall not be eliminated from the Unit Area so long as exploratory drilling operations are continued diligently with not more than four (4) months time elapsing between the completion of one exploratory well and the commencement of the next exploratory well.

4.6 With prior approval of the Supervisor, a period of time in excess of four (4) months may be allowed to elapse between the completion of one well and the commencement of the next well without the automatic elimination of nonparticipating acreage.

4.7 Unitized lands proved productive by drilling operations which serve to delay automatic elimination of lands under this Article IV shall be incorporated into a Participating Area (or Areas) in the same manner as such lands would have been incorporated in such areas had such lands been proven productive during the year preceding said fifth anniversary.

4.8 In the event nonparticipating lands are retained under this Agreement after the fifth anniversary of the initial Participating Area as a result of exploratory drilling operations, all legal subdivisions of unitized land (i.e., 40 acres by Government survey or its nearest lot or tract equivalent in instances of irregular Surveys), no part of which is entitled to be within a Participating Area shall be eliminated automatically as of the 121 day, or such later date as may be established by the Supervisor, following the completion of the last well recognized as delaying such automatic elimination beyond the fifth anniversary of the initial Participating Area established under this Agreement.

ARTICLE V—UNITIZED LAND AND UNITIZED SUBSTANCES

5.1 All land committed to this Agreement shall constitute land referred to herein as "Unitized Land". All geothermal resources in and produced from any and all formations of the Unitized Land are unitized under the terms of this agreement and herein are called "Unitized Substances."

ARTICLE VI—UNIT OPERATOR

6.1 ____________ is hereby designated as Unit Operator and by signature hereto as Unit Operator agrees and consents to accept the duties and obligations of Unit Operator for the discovery, development, production, distribution and utilization of Unitized Substances as herein provided. Whenever reference is made herein to the Unit Operator, such reference means the Unit Operator acting in that capacity and not as an owner of interest in Unitized Substances, and the term "Working Interest Owner" when used herein shall include or refer to Unit Operator as the owner of a Working Interest when such an interest is owned by it.

ARTICLE VII—RESIGNATION OR REMOVAL OF UNIT OPERATOR

7.1 Prior to the establishment of a Participating Area, hereunder, Unit Operator shall have the right to resign. Such resignation shall not become effective so as to release Unit Operator from the duties and obligations of Unit Operator or terminate Unit Operators rights, as such, for a period of six (6) months after notice of its intention to resign has been served by Unit Operator on all Working Interest Owners and the Supervisor, nor until all wells then drilled hereunder are placed in a satisfactory condition for suspension or abandonment whichever is required by the Supervisor, unless a new Unit Operator shall have been selected and approved and shall have taken over and assumed the duties and obligations of Unit Operator prior to the expiration of said period.

7.2 After the establishment of a Participating Area hereunder Unit Operator shall have the right to resign in the manner and subject to the limitations provided in 7.1 above.

7.3 The Unit Operator may, upon default or failure in the performance of its duties or obligations hereunder, be subject to removal by the same percentage vote of the owners of Working Interests as herein provided for the selection of a new Unit Operator. Such removal shall be effective upon notice thereof to the Supervisor.

7.4 The resignation or removal of Unit Operator under this Agreement shall not terminate its right, title, or interest as the owner of a Working Interest or other interest in Unitized Substances, but upon the resignation or removal of Unit Operator becoming effective, such Unit Operator shall deliver possession of all wells, equipment, material, and appurtenances used in conducting the unit operations to the new duly qualified successor Unit Operator or, if no such new unit operator is elected, to the common agent appointed to represent the Working Interest Owners in any action taken hereunder to be used for the purpose of conducting operations hereunder.

7.5 In all instances of resignation or removal, until a successor Unit Operator is selected and approved as hereinafter provided, the Working Interest Owners shall be jointly responsible for performance of the duties and obligations of Unit Operator, and shall not later than 30 days before such resignation or removal becomes effective appoint a common agent to represent them in any action to be taken hereunder.

7.6 The resignation of Unit Operator shall not release Unit Operator from any liability for any default by it hereunder occurring prior to the effective date of its resignation.

ARTICLE VIII—SUCCESSOR UNIT OPERATOR

8.1 If, prior to the establishment of a Participating Area hereunder, the Unit Operator shall resign as Operator, or shall be removed as provided in Article VII, a successor Unit Operator may be selected by vote of the owners of a majority of the Working Interests in Unitized Substances, based on their respective shares, on an acreage basis, in the Unitized Land.

8.2 If, after the establishment of a Participating Area hereunder, the Unit Operator shall resign as Unit Operator, or shall be removed as provided in Article VII, a successor Unit Operator may be selected by vote of the owners of a majority of the Working Interests in Unitized Substances, based on their respective shares, on a participating acreage basis. Provided, that, if a majority but less than 60 percent of the Working Interest in the Participating Lands is owned by the party to this agreement, a concurring vote of one or more additional Working Interest Owners owning 10 percent or more of the Working Interest in the participating land shall be required to select a new Unit Operator.

8.3 The selection of a successor Unit Operator shall not become effective until

(a) The Unit Operator so selected shall accept in writing the duties, obligations and responsibilities of the Unit Operator, and

(b) The selection shall have been approved by the Supervisor.

8.4 If no successor Unit Operator is selected and qualified as herein provided, the Director at his election may declare this Agreement terminated.

ARTICLE IX—ACCOUNTING PROVISIONS AND UNIT OPERATING AGREEMENT

9.1 Costs and expenses incurred by Unit Operator in conducting unit operations hereunder shall be paid and apportioned among and borne by the owners of Working Interests; all in accordance with the agreement or agreements entered into by and between the Unit Operator and the owners of Working Interests, whether one or more, separately or collectively.

9.2 Any agreement or agreements entered into between the Working Interest Owners and the Unit Operator as provided in this Article, whether one or more, are herein referred to as the "Unit Operating Agreement".

9.3 The Unit Operating Agreement shall provide the manner in which the Working Interest Owners shall be entitled to receive their respective share of the benefits accruing hereto in conformity with their underlying operating agreements, leases, or other contracts, and such other rights and obligations, as between Unit Operator and the Working Interest Owners.

9.4 Neither the Unit Operating Agreement nor any amendment thereto shall be deemed either to modify any of the terms and conditions of this Agreement or to relieve the Unit Operator of any right or obligation established under this Agreement.

9.5 In case of any inconsistency or conflict between this Agreement and the Unit Operating Agreement, this Agreement shall govern.

9.6 Three true copies of any Unit Operating Agreement executed pursuant to this Article IX shall be filed with the Supervisor prior to approval of this Agreement.

ARTICLE X—RIGHTS AND OBLIGATIONS OF UNIT OPERATOR

10.1 The right, privilege, and duty of exercising any and all rights of the parties hereto which are necessary or convenient for prospecting, producing, distributing or utilizing Unitized Substances are hereby delegated to and shall be exercised by the Unit Operator as provided in this Agreement in accordance with a Plan of Operations approved by the Supervisor.

10.2 Upon request by Unit Operator, acceptable evidence of title to geothermal resources interests in the Unitized Land shall be deposited with the Unit Operator, and together with this Agreement shall constitute and define the rights, privileges, and obligations of Unit Operator.

10.3 Nothing in this Agreement shall be construed to transfer title to any land or to any lease or operating agreement, it being understood that the Unit Operator, in its capacity as Unit Operator shall exercise the rights of possession and use vested in the parties hereto only for the purposes specified in this Agreement.

10.4 The Unit Operator shall take such measures as the Supervisor deems appropriate and adequate to prevent drainage of Unitized Substances from Unitized Land by wells on land not subject to this Agreement.

10.5 The Director is hereby vested with authority to alter or modify from time to time, in his discretion, the rate of prospecting and development and the quantity and rate of production under this Agreement.

ARTICLE XI—PLAN OF OPERATION

11.1 Concurrently with the submission of this Agreement for approval, Unit Operator shall submit an acceptable initial Plan of Operation. Said plan shall be as complete and adequate as the Supervisor may determine to be necessary for timely exploration and/or development and to insure proper protection of the environment and conservation of the natural resources of the Unit Area.

11.2 Prior to the expiration of the initial Plan of Operation, or any subsequent Plan of Operation, Unit Operator shall submit for approval of the Supervisor an acceptable subsequent Plan of Operation for the Unit Area which, when approved by the Supervisor, shall constitute the exploratory and/or development drilling and operating obligations of Unit Operators under this Agreement for the period specified therein.

11.3 Any plan of Operation submitted hereunder shall

(a) Specify the number and locations of any wells to be drilled and the proposed order and time for such drilling, and

(b) To the extent practicable, specify the operating practices regarded as necessary and advisable for proper conservation of natural resources and protection of the environment in compliance with section 1.1.

11.4 The Plan of Operation submitted concurrently with this Agreement for approval shall prescribe that within six (6) months after the effective date hereof, the Unit Operator shall begin to drill an adequate test well at a location approved by the Supervisor, unless on such effective date a well is being drilled conformably with the terms, hereof, and thereafter continue such drilling diligently until the ________ formation has been tested or until at a lesser depth unitized substances shall be discovered which can be produced in paying quantities (i.e., quantities sufficient to repay the costs of drilling, completing, and producing operations, with a reasonable profit) or the Unit Operator shall at any time establish to the satisfaction of the Supervisor that further drilling of said well would be unwarranted or impracticable, provided, however, that Unit Operator shall not in any event be required to drill said well to a depth in excess of _______ feet.

11.5 The initial Plan of Operation and/or subsequent Plans of Operation submitted under this article shall provide that the Unit Operator shall initiate a continuous drilling program providing for drilling of no less than one well at a time, and allowing no more than six (6) months time to elapse between completion of one well and the beginning of the next well, until a well capable of producing Unitized Substances in paying quantities is completed to the satisfaction of the Supervisor or until it is reasonably proved that the Unitized Land is incapable of producing Unitized Substances in paying quantities in the formations drilled under this Agreement.

11.6 When warranted by unforeseen circumstances, the Supervisor may grant a single extension of any or all of the critical dates for exploratory drilling operations cited in the initial or subsequent Plans of Operation. No such extension shall exceed a period of four (4) months for each well, required by the initial Plan of Operation.

11.7 Until there is actual production of Unitized Substances, the failure of Unit Operator to timely drill any of the wells provided for in Plans of Operation required under this Article XI or to timely submit an acceptable subsequent Plan of Operations, shall, after notice of default or notice of prospective default to Unit Operator by the Supervisor and after failure of Unit Operator to remedy any actual default within a reasonable time (as determined by the Supervisor), result in automatic termination of this Agreement effective as of the date of the default, as determined by the Supervisor.

11.8 Separate Plans of Operations may be submitted for separate productive zones, subject to the approval of the Supervisor. Also subject to the approval of the Supervisor, Plans of Operation shall be modified or supplemented when necessary to meet changes in conditions or to protect the interest of all parties to this Agreement.

ARTICLE XII—PARTICIPATING AREAS

12.1 Prior to the commencement of production of Unitized Substances, the Unit Operator shall submit for approval by the Supervisor a schedule (or schedules) of all land then regarded as reasonably proved to be productive from a pool or deposit discovered or developed; all lands in said schedule (or schedules), on approval of the Supervisor, will constitute a Participating Area (or Areas) effective as of the date production commences or the effective date of this Unit Agreement, whichever is later. Said schedule (or schedules) shall also set forth the percentage of Unitized Substances to be allocated, as herein provided, to each tract in the Participating Area (or Areas) so established and shall govern the allocation of production commencing with the effective date of the Participating Area.

12.2 A separate Participating Area shall be established for each separate pool or deposit of Unitized Substances or for any group thereof which is produced as a single pool or deposit and any two or more Participating Areas so established may be combined into one, on approval of the Supervisor. The effective date of any Participating Area established after the commencement of actual production of Unitized Substances shall be the first of the month in which is obtained the knowledge or information on which the establishment of said Participating Area is based, unless a more appropriate effective date is proposed by the Unit Operator and approved by the Supervisor.

12.3 Any Participating Area (or Areas) established under 12.1 or 12.2 above shall, subject to the approval of the Supervisor, be revised from time to time to include additional land then regarded as reasonably proved to be productive from the pool or deposit for which the Participating Area was established or to include lands necessary to unit operations, or to exclude land then regarded as reasonably proved not to be productive from the pool or deposit for which the Participating Area was established or to exclude land not necessary to unit operations and the schedule (or schedules) of allocation percentages shall be revised accordingly.

12.4 Subject to the limitation cited in 12.1 hereof, the effective date of any revision of a Participating Area established under Articles 12.1 or 12.2 shall be the first of the month in which is obtained the knowledge or information on which such revision is predicated, provided, however, that a more appropriate effective date may be used if justified by the Unit Operator and approved by the Supervisor.

12.5 No land shall be excluded from a Participating Area on account of depletion of the Unitized Substances, except that any Participating Area established under the provisions of this Article XII shall terminate automatically whenever all operations are abandoned in the pool or deposit for which the Participating Area was established.

12.6 Nothing herein contained shall be construed as requiring any retroactive adjustment for production obtained prior to the effective date of the revision of a Participating Area.

ARTICLE XIII—ALLOCATION OF UNITIZED SUBSTANCES

13.1 All Unitized Substances produced from a Participating Area, established under this Agreement, shall be deemed to be produced equally on an acreage basis from the several tracts of Unitized Land within the Participating Area established for such production.

13.2 For the purpose of determining any benefits accruing under this Agreement, each Tract of Unitized Land shall have allocated to it such percentage of said production as the number of acres in the Tract included in the Participating Area bears to the total number of acres of Unitized Land in said Participating Area.

13.3 Allocation of production hereunder for purposes other than for settlement of the royalty obligations of the respective Working Interest Owners, shall be on the basis prescribed in the Unit Operating Agreement whether in conformity with the basis of allocation set forth above or otherwise.

13.4 The Unitized Substances produced from a Participating Area shall be allocated as provided herein regardless of whether any wells are drilled on any particular part or tract of said Participating Area.

ARTICLE XIV—RELINQUISHMENT OF LEASES

14.1 Pursuant to the provisions of the Federal leases and 43 CFR 3245.1, a lessee of record shall, subject to the provisions of the Unit Operating Agreement, have the right to relinquish any of its interests in leases committed hereto, in whole or in part; provided, that no relinquishment shall be made of interests in land within a Participating Area without the prior approval of the Director.

14.2 A Working Interest Owner may exercise the right to surrender, when such right is vested in it by any non-Federal lease, sublease, or operating agreement, provided that each party who will or might acquire the Working Interest in such lease by such surrender or by forfeiture is bound by the terms of this Agreement, and further provided that no relinquishment shall be made of such land within a Participating Area without the prior written consent of the non-Federal Lessor.

14.3 If as the result of relinquishment, surrender, or forfeiture the Working Interests become vested in the fee owner or lessor of the Unitized Substances, such owner may:

(1) Accept those Working Interest rights and obligations subject to this Agreement and the Unit Operating Agreement; or

(2) Lease the portion of such land as is included in a Participating Area established hereunder, subject to this Agreement and the Unit Operating Agreement; and provide for the independent operation of any part of such land that is not then included within a Participating Area established hereunder.

14.4 If the fee owner or lessor of the Unitized Substances does not, (1) accept the Working Interest rights and obligations subject to this Agreement and the Unit Operating Agreement, or (2) lease such lands as provided in 14.3 above within six (6) months after the relinquished, surrendered, or forfeited Working Interest becomes vested in said fee owner or lessor, the Working Interest benefits and obligations accruing to such land under this Agreement and the Unit Operating Agreement shall be shared by the owners of the remaining unitized Working Interests in accordance with their respective Working Interest ownerships, and such owners of Working Interests shall compensate the fee owner or lessor of Unitized Substances in such lands by paying sums equal to the rentals, minimum royalties, and royal-

ties applicable to such lands under the lease or leases in effect when the Working Interests were relinquished, surrendered, or forfeited.

14.5 Subject to the provisions of 14.4 above, an appropriate accounting and settlement shall be made for all benefits accruing to or payments and expenditures made or incurred on behalf of any surrendered or forfeited Working Interest subsequent to the date of surrender or forfeiture, and payment of any moneys found to be owing by such an accounting shall be made as between the parties within thirty (30) days.

14.6 In the event no Unit Operating Agreement is in existence and a mutually acceptable agreement cannot be consummated between the proper parties, the Supervisor may prescribe such reasonable and equitable conditions of agreement as he deems warranted under the circumstances.

14.7 The exercise of any right vested in a Working Interest Owner to reassign such Working Interest to the party from whom obtained shall be subject to the same conditions as set forth in this Article XIV in regard to the exercise of a right to surrender.

ARTICLE XV—RENTALS AND MINIMUM ROYALTIES

15.1 Any unitized lease on non-Federal land containing provisions which would terminate such lease unless drilling operations are commenced upon the land covered thereby within the time therein specified or rentals are paid for the privilege of deferring such drilling operations, the rentals required thereby shall, notwithstanding any other provisions of this Agreement, be deemed to accrue as to the portion of the lease not included within a Participating Area and become payable during the term thereof as extended by this Agreement, and until the required drillings are commenced upon the land covered thereby.

15.2 Rentals are payable on Federal leases on or before the anniversary date of each lease year; minimum royalties accrue from the anniversary date of each lease year and are payable at the end of the lease year.

15.3 Beginning with the lease year commencing on or after ____________ and for each lease year thereafter, rental or minimum royalty for lands of the United States subject to this Agreement shall be made on the following basis:

(a) An advance annual rental in the amount prescribed in unitized Federal leases, in no event creditable against production royalties, shall be paid for each acre or fraction thereof which is not within a Participating Area.

(b) A minimum royalty shall be charged at the beginning of each lease year (such minimum royalty to be due as of the last day of the lease year and payable within thirty (30) days thereafter) of $2 an acre or fraction thereof, for all Unitized Acreage within a Participating Area as of the beginning of the lease year. If there is production during the lease year the deficit, if any, between the actual royalty paid and the minimum royalty prescribed herein shall be paid.

15.4 Rental or minimum royalties due on leases committed hereto shall be paid by Working Interest Owners responsible therefor under existing contracts, laws, and regulations, or by the Unit Operator.

15.5 Settlement for royalty interest shall be made by Working Interest Owners responsible therefor under existing contracts, laws, and regulations, or by the Unit Operator, on or before the last day of each month for Unitized Substances produced during the preceding calendar month.

15.6 Royalty due the United States shall be computed as provided in the operating regulations and paid in value as to all Unitized Substances on the basis of the amounts thereof allocated to unitized Federal land as provided herein at the royalty rate or rates specified in the respective Federal leases.

15.7 Nothing herein contained shall operate to relieve the lessees of any land from their respective lease obligations for the payment of any rental, minimum royalty, or royalty due under their leases.

ARTICLE XVI—OPERATIONS ON NONPARTICIPATING LAND

16.1 Any party hereto owning or controlling the Working Interest in any Unitized Land having thereon a regular well location may, with the approval of the Supervisor and at such party's sole risk, costs, and expense, drill a well to test any formation of deposit for which a Participating Area has not been established or to test any formation or deposit for which a Participating Area has been established if such location is not within said Participating Area, unless within 30 days of receipt of notice from said party of his intention to drill the well, the Unit Operator elects and commences to drill such a well in like manner as other wells are drilled by the Unit Operator under this Agreement.

16.2 If any well drilled by a Working Interest Owner other than the Unit Operator proves that the land upon which said well is situated may properly be included in a Participating Area, such Participating Area shall be established or enlarged as provided in this Agreement and the well shall thereafter be operated by the Unit Operator in accordance with the terms of this Agreement and the Unit Operating Agreement.

ARTICLE XVII—LEASES AND CONTRACTS CONFORMED AND EXTENDED

17.1 The terms, conditions, and provisions of all leases, subleases, and other contracts relating to exploration, drilling, development, or utilization of geothermal resources on lands committed to this Agreement, are hereby expressly modified and amended only to the extent necessary to make the same conform to the provisions hereof, otherwise said leases, subleases, and contracts shall remain in full force and effect.

17.2 The parties hereto consent that the Secretary shall, by his approval hereof, modify and amend the Federal leases committed hereto and the regulations in respect thereto to the extent necessary to conform said leases and regulations to the provisions of this Agreement.

17.3 The development and/or operation of lands subject to this Agreement under the terms hereof shall be deemed full performance of any obligations for development and operation with respect to each and every separately owned tract subject to this Agreement, regardless of whether there is any development of any particular tract of the Unit Area.

17.4 Drilling and/or producing operations performed hereunder upon any tract of Unitized Lands will be accepted and deemed to be performed upon and for the benefit of each and every tract of Unitized Land.

17.5 Suspension of operations and/or production on all Unitized Lands pursuant to direction or consent of the Secretary or his duly authorized representative shall be deemed to constitute such suspension pursuant to such direction or consent as to each and every tract of Unitized Land. A suspension of operations and/or production limited to specified lands shall be applicable only to such lands.

17.6 Subject to the provisions of Article XV hereof and 17.10 of this Article, each lease, sublease, or contract relating to the exploration, drilling, development, or utilization of geothermal resources of lands other than those of the United States committed to this Agreement, is hereby extended beyond any such term so provided therein so that it shall be continued for and during the term of this Agreement.

17.7 Subject to the lease renewal and the readjustment provision of the Act, any Federal lease committed hereto may, as to the Unitized Lands, be continued for the term so provided therein, or as extended by law. This subsection shall not operate to extend any lease or portion thereof as to lands excluded from the Unit Area by the contraction thereof.

17.8 Each sublease or contract relating to the operations and development of Unitized Substances from lands of the United States committed to this Agreement shall be continued in force and effect for and during the term of the underlying lease.

17.9 Any Federal lease heretofore or hereafter committed to any such unit plan embracing lands that are in part within and in part outside of the area covered by any such plan shall be segregated into separate leases as to the lands committed and the lands not committed as of the effective date of unitization.

17.10 In the absence of any specific lease provision to the contrary, any lease, other than a Federal lease, having only a portion of its land committed hereto shall be segregated as to the portion committed and the portion not committed, and the provisions of such lease shall apply separately to such segregated portions commencing as of the effective date hereof. In the event any such lease provides for a lump-sum rental payment, such payment shall be prorated between the portions so segregated in proportion to the acreage of the respective tracts.

17.11 Upon termination of this Agreement, the leases covered hereby may be maintained and continued in force and effect in accordance with the terms, provisions, and conditions of the Act, the lease or leases, and amendments thereto.

ARTICLE XVIII—EFFECTIVE DATE AND TERM

18.1 This Agreement shall become effective upon approval by the Secretary or his duly authorized representative and shall terminate five (5) years from said effective date unless,

(a) Such date of expiration is extended by the Director, or

(b) Unitized Substances are produced or utilized in commercial quantities in which event this Agreement shall continue for so long as Unitized Substances are produced or utilized in commercial quantities, or

(c) This Agreement is terminated prior to the end of said five (5) year period as heretofore provided.

18.2 This Agreement may be terminated at any time by the owners of a majority of the Working Interests, on an acreage basis, with the approval of the Supervisor. Notice of any such approval shall be given by the Unit Operator to all parties hereto.

ARTICLE XIX—APPEARANCES

19.1 Unit Operator shall, after notice to other parties affected, have the right to appear for and on behalf of any and all interests affected hereby before the Department of the Interior, and to appeal from decisions, orders or rulings issued under the regulations of said Department, or to apply for relief from any of said regulations or in any proceedings relative to operations before the Department of the Interior or any other legally constituted authority: *Provided, however*, That any interested parties shall also have the right, at its own expenses, to be heard in any such proceeding.

ARTICLE XX—NO WAIVER OF CERTAIN RIGHTS

20.1 Nothing contained in this Agreement shall be construed as a waiver by any party

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hereto of the right to assert any legal or constitutional right or defense pertaining to the validity or invalidity of any law of the State wherein lands subject to this Agreement are located, or of the United States, or regulations issued thereunder, in any way affecting such party or as a waiver by any such party of any right beyond his or its authority to waive.

ARTICLE XXI—UNAVOIDABLE DELAY

21.1 The obligations imposed by this Agreement requiring Unit Operator to commence or continue drilling or to produce or utilize Unitized Substances from any of the land covered by this Agreement, shall be suspended while, but only so long as, Unit Operator, despite the exercise of due care and diligence, is prevented from complying with such obligations, in whole or in part, by strikes, Acts of God, Federal or other applicable law, Federal or other authorized governmental agencies, unavoidable accidents, uncontrollable delays in transportation, inability to obtain necessary materials in open market, or other matters beyond the reasonable control of Unit Operator, whether similar to matters herein enumerated or not.

21.2 No unit obligation which is suspended under this section shall become due less than thirty (30) days after it has been determined that the suspension is no longer applicable.

21.3 Determination of creditable "Unavoidable Delay" time shall be made by the Unit Operator subject to approval of the Supervisor.

ARTICLE XXII—POSTPONEMENT OF OBLIGATIONS

22.1 Notwithstanding any other provisions of this Agreement, the Director, on his own initiative or upon appropriate justification by Unit Operator, may postpone any obligation established by and under this Agreement to commence or continue drilling or to operate on or produce Unitized Substances from lands covered by this Agreement when in his judgement, circumstances warrant such action.

ARTICLE XXIII—NONDISCRIMINATION

23.1 In connection with the performance of work under this Agreement, the Operator agrees to comply with all of the provisions of section 202 (1) to (7) inclusive, of Executive Order 11246 (30 F.R. 12319), as amended by Executive Order 11375 (32 F.R. 14303), which are hereby incorporated by reference in this Agreement.

ARTICLE XXIV—COUNTERPARTS

24.1 This Agreement may be executed in any number of counterparts no one of which needs to be executed by all parties, or may be ratified or consented to by separate instruments in writing specifically referring hereto, and shall be binding upon all parties who have executed such a counterpart, ratification or consent hereto, with the same force and effect as if all such parties had signed the same document.

ARTICLE XXV—SUBSEQUENT JOINDER

25.1 If the owner of any substantial interest in geothermal resources under a tract within the Unit Area fails or refuses to subscribe or consent to this Agreement, the owner of the Working Interest in that tract may withdraw said tract from this Agreement by written notice delivered to the Supervisor and the Unit Operator prior to the approval of this Agreement by the Supervisor.

25.2 Any geothermal resources interests in lands within the Unit Area not committed hereto prior to approval of this Agreement may thereafter be committed by the owner or owners thereof subscribing or consenting to this Agreement, and, if the interest is a Working Interest, by the owner of such interest also subscribing to the Unit Operating Agreement.

25.3 After operations are commenced hereunder, the right of subsequent joinder, as provided in this Article XXV, by a working interest Owner is subject to such requirements or approvals, if any, pertaining to such joinder, as may be provided for in the Unit Operating Agreement. Joinder to the Unit Agreement by a Working Interest Owner, at any time, must be accompanied by appropriate joinder to the Unit Operating Agreement, if more than one committed Working Interest Owner is involved, in order for the interest to be regarded as committed to this Unit Agreement.

25.4 After final approval hereof, joinder by a nonworking interest owner must be consented to in writing by the Working Interest Owner committed hereto and responsible for the payment of any benefits that may accrue hereunder in behalf of such nonworking interest. A nonworking interest may not be committed to this Agreement unless the corresponding Working Interest is committed hereto.

25.5 Except as may otherwise herein be provided, subsequent joinders to this Agreement shall be effective as of the first day of the month following the filing with the Supervisor of duly executed counterparts of all or any papers necessary to establish effective commitment of any tract to this Agreement unless objection to such joinder is duly made within sixty (60) days by the Supervisor.

ARTICLE XXVI—COVENANTS RUN WITH THE LAND

26.1 The covenants herein shall be construed to be covenants running with the land with respect to the interest of the parties hereto and their successors in interest until this Agreement terminates, and any grant, transfer, or conveyance, of interest in land or leases subject hereto shall be and hereby is conditioned upon the assumption of all privileges and obligations hereunder by the grantee, transferee, or other successor in interest.

26.2 No assignment or transfer of any Working Interest or other interest subject hereto shall be binding upon Unit Operator until the first day of the calendar month after Unit Operator is furnished with the original, photostatic, or certified copy of the instrument of transfer.

ARTICLE XXVII—NOTICES

27.1 All notices, demands or statements required hereunder to be given or rendered to the parties hereto shall be deemed fully given if given in writing and personally delivered to the party or sent by postpaid registered or certified mail, addressed to such party or parties at their respective addresses set forth in connection with the signatures hereto or to the ratification or consent hereof or to such other address as any such party may have furnished in writing to party sending the notice, demand or statement.

ARTICLE XXVIII—LOSS OF TITLE

28.1 In the event title to any tract of Unitized Land shall fail and the true owner cannot be induced to join in this Agreement, such tract shall be automatically regarded as not committed hereto and there shall be such readjustment of future costs and benefits as may be required on account of the loss of such title.

28.2 In the event of a dispute as to title as to any royalty, Working Interest, or other interests subject hereto, payment or delivery on account thereof may be withheld without liability for interest until the dispute is finally settled: *Provided*, That, as to Federal land or leases, no payments of funds due the United States shall be withheld, but such funds shall be deposited as directed by the Supervisor to be held as unearned money pending final settlement of the title dispute, and then applied as earned or returned in accordance with such final settlement.

ARTICLE XXIX—TAXES

29.1 The Working Interest Owners shall render and pay for their accounts and the accounts of the owners of nonworking interests all valid taxes on or measured by the Unitized Substances in and under or that may be produced, gathered, and sold or utilized from the land subject to this Agreement after the effective date hereof.

29.2 The Working Interest Owners on each tract may charge a proper proportion of the taxes paid under 29.1 hereof to the owners of nonworking interests in said tract, and may reduce the allocated share of each royalty owner for taxes so paid. No taxes shall be charged to the United States or the State of ____________ or to any lessor who has a contract with his lessee which requires the lessee to pay such taxes.

ARTICLE XXX—RELATION OF PARTIES

30.1 It is expressly agreed that the relation of the parties hereto is that of independent contractors and nothing in this Agreement contained, expressed, or implied, nor any operations conducted hereunder, shall create or be deemed to have created a partnership or association between the parties hereto or any of them.

ARTICLE XXXI—SPECIAL FEDERAL LEASE STIPULATIONS AND/OR CONDITIONS

31.1 Nothing in this Agreement shall modify special lease stipulations and/or conditions applicable to lands of the United States. No modification of the conditions necessary to protect the lands or functions of lands under the jurisdiction of any Federal agency is authorized except with prior consent in writing whereby the authorizing official specifies the modification permitted.

In witness whereof, the parties hereto have caused this Agreement to be executed and have set opposite their respective names the date of execution.

Witnesses:	Unit operator (as unit operator and as working interest owner)
____________________	____________________
____________________	By ____________________
Witnesses:	Working Interest Owners:
____________________	____________________
____________________	By ____________________
Witnesses:	Other Interest Owners:
____________________	____________________
____________________	By ____________________

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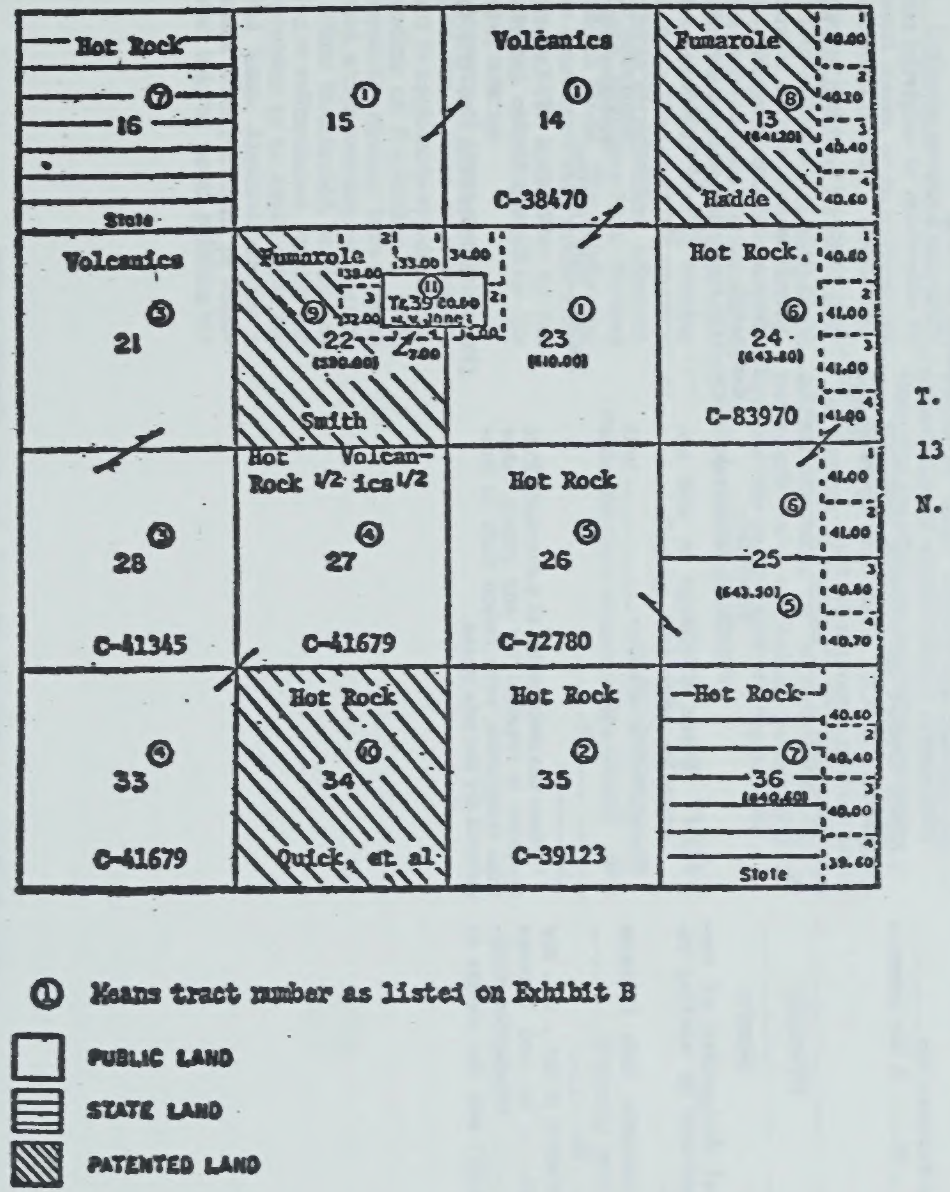
§ 271.13 Sample form of exhibit A of unit agreement.

EXHIBIT A—BIG VAPOR UNIT AREA, T. 13 N., R. 10 W., M.D.M., California
R. 1 W.



§ 271.14 Sample form of exhibit B of unit agreement.

EXHIBIT B—BIG VAPOR UNIT AREA, NAPA COUNTY, CALIF., T. 13 N., R. 10 W.

Tract No.	Description of land	No. of acres	Serial No. and expiration date of lease	Basic royalty and ownership percentage	Lessee of record	Working interest and percentage
	Federal land		*California serials*			
1	Sec. 14: All. Sec. 15: All. Sec. 23: Lots 1, 2, S½, NE¼, E½NW¼.	1,890.00	38470 July 31, 1982	United States: All	Volcanics, Inc.	Volcanics, Inc: All.
2	Sec. 35: All	640.00	39123 July 31, 1982.	do	D. H. Boller	Hot Rock Co.: All.
3	Sec. 21: All. Sec. 28: All.	1,280.00	41345 July 31, 1982.	do	C. S. Waters—50%. D. F. Mann—50%	Volcanics, Co.: 50%. Hot Rock Co.: 50%.
4	Sec. 27: All. Sec. 33: All.	1,280.00	41679	do	H. C. Pipes	Fumarole Ltd.: All.
5	Sec. 26: All. Sec. 25: S½.	961.80	71278 Sept. 31, 1982.	do	Hot Rock Co	Hot Rock Co.: All.
6	Sec. 24: All. Sec. 25: N½.	965.80	83970 Application.	do	H. C. Pipes	Do.
	6 Federal tracts 7,017.30 acres or 68.47% of unit area.					
	California State land					
7	Sec. 16: All. Sec. 36: All.	1,280.60	65-67430	State of California: All.	Hot Rock Co	Hot Rock Co.: All.
	1 State tract 1,280.60 acres or 12.49% of unit area.					
	Patented land					
8	Sec. 13: All	641.20	June 30, 1979	I. B. Hadde: All	Fumarole, Ltd	Fumarole, Ltd.: All.
9	Sec. 22: Lots 1, 2, 3, 4, S½, NW¼.	590.00	Feb. 28, 1981	J. P. Smith: All	do	Do.
10	Sec. 34: All	640.00	Mar. 31, 1981	A. G. Quick: 75%. P. T. Land: 25%.	Hot Rock Co	Hot Rock Co.: All.
11	Tract 39	80.00	Apr. 30, 1981	M. V. Jones: All	Unleased	M. V. Jones: All.
	3 Patented tracts 1,951.20 acres or 19.04% of unit area.					
	Total. 11 tracts 10,249.10 acres in entire unit area.					

§ 271.15 Form of collective bond.

COLLECTIVE CORPORATE SURETY

Known all men by these presents, That we, ____________ signing as Princi-
(Name of Unit Operator)
pal, for and on behalf of the record owners of unitized substances now or hereafter covered by the unit agreement for this ____________, approved ____________,
(Name of Unit) (Date)
____________, as Surety are
(Name and address of Surety)
jointly and severally held and firmly bound unto the United States of America in the sum of ____________ Dollars,
(Amount of bond)
lawful money of the United States, for the use and benefit of and to be paid to the United States and any entryman or patentee of any portion of the unitized land, heretofore entered or patented with the reservation of the geothermal resources deposits to the United States, for which payment well and truly to be made, we bind ourselves, and each of us, and each of our heirs, executors, administrators, successors, and assigns by these presents.

The condition of the foregoing obligation is such that, whereas the Secretary on ____________ approved under the provisions
(Date)
of the Geothermal Steam Act of 1970, a unit agreement for the development and operation of the ____________;
(Name of Unit and State)
and

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Whereas said Principal and record owners of unitized substances, pursuant to said unit agreement, have entered into certain covenants and agreements as set forth therein, under which operations are to be conducted; and

Whereas said Principal as Unit Operator has assumed the duties and obligations of the respective owners of unitized substances as defined in said unit agreement; and

Whereas said Principal and surety agree to remain bound in the full amount of the bond for failure to comply with the terms of the unit agreement, and the payment of rentals, minimum royalties, and royalties due under the Federal leases committed to said unit agreement; and

Whereas the Surety hereby waives any right of notice of and agrees that this bond may remain in force and effect notwithstanding:

(a) Any additions to or change in the ownership of the unitized substances herein described.

(b) Any suspension of the drilling or producing requirements or waiver, suspension or reduction of rental or minimum royalty payments or reduction of royalties pursuant to applicable laws or regulations thereunder; and

Whereas said Principal and Surety agree to the payment of compensatory royalty under the regulations of the Interior Department in lieu of drilling necessary offset wells in the event of drianage; and

Whereas nothing herein contained shall preclude the United States from requiring an additional bond at any time when deemed necessary:

Now, therefore, if the said Principal shall faithfully comply with all of the provisions of the above-identified unit agreement and with the terms of the leases committed thereto, then the above obligation is to be of no effect; otherwise to remain in full force and virtue.

Signed, sealed, and delivered this ---------- day of ------------, 19----, in the presence of:

Witnesses:

-------------------- --------------------
(Principal)

-------------------- --------------------
(Surety)

§ 271.16 Form of designation of successor unit operator by working interest owners.

Designation of successor Unit Operator ------------, Unit Area, County of --------- State of ------------, No. ------.

This indenture, dated as of the ------ day of ------------, 19----, by and between ------------------------ hereinafter designated as "First Party," and the owners of unitized working interest, hereinafter designated as "Second Parties,"

Witnesseth: Whereas under the provisions of the Geothermal Steam Act of December 24, 1970, 84 Stat. 1566, the Secretary on the ------ day of ------------, 19----, approved a unit agreement for the ------------ Unit Area, wherein ------------ is designated as Unit Operator; and

Whereas said ------------------------- has resigned as such Operator,[1] and the designation of a successor Unit Operator is now required pursuant to the terms thereof; and

Whereas First Party has been and hereby is designated by Second Parties as a Unit Operator, and said First Party desires to assume all the rights, duties, and obligations of Unit Operator under the said unit agreement.

Now, therefore, in consideration of the premises hereinbefore set forth and the promises hereinafter stated, the First Party hereby covenants and agrees to fulfill the duties and assume the obligations of Unit Operator under and pursuant to all the terms of the ------------ unit agreement, and the Second Parties covenant and agree that, effective upon approval of this indenture by the Supervisor, of the Geological Survey, First Party shall be granted the exclusive right and privilege of exercising any and all rights and privileges and Unit Operator, pursuant to the terms and conditions of said unit agreement; said unit agreement being hereby incorporated herein by references and made a part hereof as fully and effectively as though said unit agreement were expressly set forth in this instrument.

In witness whereof, the parties hereto have executed this instrument as of the date hereinabove set forth.

------------------- -------------------
(First Party)

(Witnesses)

------------------- -------------------
(Second Party)

(Witnesses)

I hereby approve the foregoing indenture designating ------------ as Unit Operator under the unit agreement for the ---------- Unit Area, this ------ day of ------------, 19----.

Supervisor,
U.S. Geological Survey.

§ 271.17 Form of change in unit operator by assignment.

Change in Unit Operator ------------ unit Area, County of ------------, State of ------------, No. ------.

[1] Where the designation of a successor Unit Operator is required for any reason other than resignation, such reason shall be substituted for the one stated.

This indenture, dated as of the ------ day of ------------, 19----, by and between ------------------------ hereinafter designated as "First Party," and --------------- ---------, hereinafter designated as "Second Party."

Witnesseth: Whereas under the provisions of the Geothermal Steam Act of December 24, 1970, 84 Stat. 1566, the Secretary on the ------ day of ------------, 19----, approved a unit agreement for the ------------ Unit Area, wherein the First Party is designated as Unit Operator; and

Whereas the First Party desires to transfer, assign, release, and quitclaim, and the Second Party desires to assume all the rights, duties, and obligations of Unit Operator under the unit agreement; and

Whereas for sufficient and valuable consideration, the receipt whereof is hereby acknowledged, the First Party has transferred, conveyed and assigned all his/its rights under certain operating agreements involving lands within the area set forth in said unit agreement unto the Second Party:

Now, therefore, in consideration of the premises hereinbefore set forth, the First Party does hereby transfer, assign, release, and quitclaim unto Second Party all of First Party's rights, duties and obligations as Unit Operator under said unit agreement; and

Second Party hereby accept this assignment and hereby convenants and agrees to fulfill the duties and assume the obligations of Unit Operator under and pursuant to all the terms of said unit agreement to the full extent set forth in this assignment, effective upon approval of this indenture by the Supervisor of the Geological Survey; said unit agreement being hereby incorporated herein by reference and made a part hereof as fully and effectively as though said unit agreement were expressly set forth in this instrument.

In witness whereof, the parties hereto have executed this instrument as of the date hereinabove set forth.

-------------------- --------------------
(First Party)

(Witnesses)

-------------------- --------------------
(Second Party)

(Witnesses)

I hereby approve the foregoing indenture designated ------------------------ as Unit Operator under the unit agreement for the ------------ Unit Area, this ------ day of ------------, 19----.

Supervisor, U.S.
Geological Survey

Dated: July 18, 1973.

William W. Lyons,
Deputy Under Secretary of the Interior.

[FR Doc.73-15058 Filed 7-20-73;8:45 am]

Proposed Rules

This section of the FEDERAL REGISTER contains notices to the public of the proposed issuance of rules and regulations. The purpose of these notices is to give interested persons an opportunity to participate in the rulemaking prior to the adoption of the final rules.

DEPARTMENT OF THE INTERIOR

Bureau of Land Management

[43 CFR Parts 3000, 3200]

GEOTHERMAL RESOURCES

Leasing on Public, Acquired, and Withdrawn Lands; Correction and Extension of Comment Period

The purpose of this notice is to correct the inadvertent omission of § 3230.1–5 from the proposed geothermal regulations published in the FEDERAL REGISTER on July 23, 1973 (38 FR 19748). Section 3230.1–5 sets forth evidence requirements for qualifying to convert claimed geothermal rights to geothermal leases. In addition, this notice clarifies the proposed regulations by correcting several lesser errors.

The time for submission of written comments, suggestions, or objections, with respect to 43 CFR, Parts 3000 and 3200, proposed July 23, 1973, and § 3230.1–5 appearing below, to the Geothermal Coordinator, Department of the Interior, Washington, D.C. 20240, is hereby extended from August 22, 1973 to September 5, 1973.

1. A new § 3230.1–5 is added to Subpart 3230 of the proposed regulations to read:

§ 3230.1–5 Evidence required to qualify for grant of rights to conversion to geothermal leases, or to applications for geothermal leases.

(a) Any person claiming rights to conversion to a geothermal lease must show to the reasonable satisfaction of the authorized officer that substantial expenditures for the exploration, development or production of geothermal steam were made by the applicant who is seeking the conversion on the lands for which a lease is sought or on adjoining, adjacent or nearby lands, including both Federal and non-Federal lands. The substantial expenditures must have been made prior to December 24, 1970, and either by the applicant seeking conversion or by his predecessors in interest.

(b) For purposes of these regulations, an application for a lease or a permit, filed pursuant to applicable mineral leasing acts, pending on September 7, 1965, which subsequently ripened into a lease or permit, and which remains outstanding or has either terminated, expired or been canceled or relinquished, retains the right to conversion to an application for a geothermal lease. Applications for a lease or permit, filed pursuant to applicable mineral leasing acts, pending on September 7, 1965, which were subsequently withdrawn, retain the right to conversion to an application for a geothermal lease. Leases or permits issued pursuant to the applicable mineral leasing acts and outstanding on September 7, 1965, which were subsequently terminated, expired, or were canceled or relinquished, retain the right to conversion to a geothermal lease.

2. Section 3203.3 is corrected to read:

§ 3203.3 Consolidation of leases.

Two or more contiguous leases issued to the same lessee may be consolidated if the total combined acreage does not exceed 2,560 acres, except where a larger acreage is caused by an irregular subdivision or subdivisions as stated in 3203.2.

§ 3241.1–1 [Corrected]

3. Section 3241.1–1 is corrected by deleting "is less than 1,280 acres occasioned by" from paragraph (a)(1).

4. Section 3241.2–2 is corrected to read:

§ 3241.2–2 Number of copies required.

Three copies of all instruments of assignment or transfer, and a single copy of any additional information required by § 3202 of these regulations relating to citizenship or qualifications of corporations and associations, including partnerships, must be filed in the proper BLM Office.

5. Section 3243.4–1 is corrected by: Adding the letter "s" to corporation in paragraph (a); relettering paragraphs (c) and (d) as (b) and (c) respectively.

Dated: August 3, 1973.

W. W. LYONS,
Deputy Under Secretary of the Interior.

[FR Doc.73-16335 Filed 8-7-73;8:45 am]

B. ENVIRONMENTAL IMPACT OF THE PROPOSED ACTION

1. General

Regardless of the location, geothermal operations and activities generally will follow a sequence of exploration, testing, development where production is obtained, and abandonment after completion of testing if unsuccessful or after production ceases. The environmental impacts of the development and use of geothermal steam and associated geothermal resources would be dependent upon a number of factors, including biological, geographic, geologic, physical, clamatological, and demographic characteristics of the area to be developed. In addition, the mineral resources as well as the aesthetic, scenic, recreational, agricultural, industrial, and other potential land uses must be considered. Other important factors are the physical and chemical character of the steam and/or associated fluids, the relationship between the geothermal reservoirs and fresh water reservoirs, and the extent and energy content of the geothermal resource. Environmental evaluations also must recognize the potential environmental benefits which may be derived from the utilization of this resource in relationship to an equivalent amount of energy derived from alternative sources. If geothermal exploration, development, and production activities are properly planned, regulated, conducted, and operated, these resources may provide an environmentally acceptable energy source.

The two basic types of geothermal systems pose quite different environmental problems. The vapor-dominated systems generally yield relatively pure steam with minor amounts of other gases, minerals, etc. such as boron, carbon dioxide, hydrogen, methane, nitrogen, hydrogen sulfide, mercury, radon, and ammonia. Analysis of condensates of such vapors commonly indicates a water containing predominantly dissolved ammonium and bicarbonate ions.

Hot-watersystems may yield hot mineralized or saline waters containing a wide variety of metallic salts and silica. In the Salton Sea KGRA, the geothermal fluid is a highly concentrated brine. In other areas, such as Oregon and Idaho, the hot waters may be of sufficient purity to be used directly for irrigation or other fresh water uses.

Development and production of geothermal resources involve six phases: exploration, test drilling, production testing, field development, powerplant and powerline construction, and full-scale operations. Each phase would have differing impacts on the environment depending upon the potential of the geothermal resources and the varying relationship with other actual and potential resources.

2. Exploration

The exploration of both known and potential geothermal areas are designed to locate and define commercial geothermal reservoirs and to evaluate the impact of possible geothermal development upon the environment, including surface and subsurface resources and various land uses. Principal exploration activities include topographic and geologic mapping,

geologic field examinations, ground and spring temperature surveys, geochemical studies, geophysical surveys, and shallow drilling for the purpose of sampling surficial ground waters, temperature measurement, and subsurface rock sampling. These exploration activities are surface-oriented investigations which can, if not properly planned, conducted, and regulated, lead to temporary environmental damage from activities such as movement of field parties over access roads or cross country and shallow drilling required for geophysical exploration.

Exploration operations conducted prior to obtaining a geothermal lease may involve both airborne explorations, which do not require physical presence on the ground, or surface exploration. Surface exploration includes both casual use, which generally does not result in significant disturbance of the environment (such as small field crews with no off-road vehicles or crews using lightweight vehicles on existing roads and trails), or intensive use which may result in serious disturbance of the environment to varying degrees. Intensive use can involve actions such as construction of temporary access roads or trails, clearing of vegetative cover for an exploration site, movement of heavy equipment and vehicles cross country, etc.

(a) Airborne Exploration - Small aircraft and helicopters are used to conduct a variety of exploration surveys. Low altitude geologic reconnaissance flights at 100 to 500 feet are made for heat and magnetic sensing and to visually search for rock outcrops to give structural indications and lithologic data, both of which are studied later by surface exploration methods. High altitude flights above 3,000 feet are made to conduct photographic, sensing, geophysical magnetometer and geologic visual reconnaissance surveys.

(b) Surface Exploration - Casual use activities include the use of existing roads and trails to conduct a variety of surveys such as:

- Geochemical surveys where water and vegetative samples are obtained and analyzed for their chemical content.
- Stratigraphic, lithologic and structural mapping where a geologist assisted by a survey crew examines the rock outcrops and topography in an area and makes surveys of these data points.
- Micro gas surveys where air samples are obtained from various points within a given area.
- Reconnaissance surveys where the surface features and natural phenomena are examined without disturbing the land.

Intensive use consists of activities related to the search for evidence of geothermal indicators which require physical presence upon the land and can result in significant disturbance of the environment (roads, clearing, etc.).

Whenever there is an increase in human activity, the potential for accidental brush or forest fires increases. Sparks from equipment, burning of waste materials, and carelessness with combustible materials may result in accidental fires. Although the potential for accidental fires will vary from one geothermal field to the next, the fire hazard at any particular site is expected to remain about the same throughout the various phases of geothermal development. Adequate fire prevention measures can be taken to mitigate this risk. Accidental fires can cause increased

erosion and stream sedimentation, increased air pollution, loss of valuable timber resources, loss of wildlife habitat, loss of surface geothermal related structures, etc.

3. Test Drilling

Locations for the drilling of test wells would be selected on the basis of preliminary exploration work, an approved exploration plan, and other data. Test wells provide subsurface geologic data, locate potential productive zones within the geothermal reservoir, help delineate the reservoir limits, and aid in determining the physical and chemical properties of the reservoir and reservoir fluids.

The test drilling equipment used often is a truck-mounted drilling rig and possibly a truck-mounted air compressor if the drilling is done with air or a water tank truck if the drilling is done with water. The drill site occupies an area of approximately 40 x 60 feet, or it may be in the center of a new or existing trail. In some cases, a drilling rig with a conventional substructure is used. The drill site (or pad) generally involves an area of less than an acre which may be cleared of vegetation and graded to a flat surface. The drilling rig, mud pumps, mud tanks, generators, drill pipe rack, tool house, etc. usually are located on the drill pad. Other facilities such as storage tanks for water and fuel may or may not be on the drill pad; however, they will be nearby. A reserve pit of approximately 1,000 square feet and 6 to 8 feet deep is sometimes dug to contain waste fluids during drilling operations.

Where larger equipment is used, it may be necessary to construct a heavy duty road that can support the drilling rig and other equipment that must be moved to the location. The shortest feasible route should be used to reduce costs, environmental disturbances, and haul time. The roads may cross small streams with or without the use of culverts; however, they are not designed for permanent access. Depending on soil conditions, the well site and roads may or may not be gravelled.

Operation of gasoline powered motor vehicles used to move men and supplies and diesal powered trucks, drill rigs, and construction equipment necessary for test drilling and subsequent development phases can contribute pollutants to the atmosphere. The quantity of pollutants from internal combustion engines is expected to be small in comparison to pollution from present vehicular movements over existing local roads, but vehicular movement related to geothermal activity will result in some increase in the pollution load to the local atmosphere.

Particulate matter, in quantities greater than natural wind-blown dust or dust generated by present vehicular movement over untreated local roads, will be added to the atmosphere as a result of geothermal related vehicular movement on untreated or unsurfaced roads and from earthmoving activity during construction of drill pads and related construction projects. Construction activity will also create temporary vegetation-free sites, which may be subject to a greater degree of wind erosion than natural undisturbed ground. Dust generated as a result of geothermal related activity would contribute to the degradation of air quality in

the vicinity of the geothermal development. Quantitative measurements of the potential increase in particulates as a result of geothermal activity have not been documented, but no serious impacts are anticipated. In addition to possible degradation of air quality, the settling of particulates on surrounding plant life may have some influence on their growth and survival.

Current drilling equipment, technology, and methods are similar to those used in oil and gas operation, with modifications to suit the specific needs of geothermal drilling (Figure III-1). Equipment, such as derricks, substructures, mud-circulation systems, drill strings, casing, well-head equipment, cements, and cementing equipment must be suitable for the drilling assignment or the health and safelty of employees may be jeopardized and the possibility of blowout or other environmental hazards may be increased. Backfilling of mud pits and fluid ponds, use of blowout preventers, and casing and cementing of the well (Figure III-2) will be required to limit any adverse environmental impact at the immediate well site. If a test well is to be abandoned, the well should be properly plugged. A well yielding only fresh water could be developed as a fresh water source. Improper abandonment of field camps could contribute to degradation of the environment by trash, drilling wastes, unrestored surface disturbance, etc.

Blowouts, in which steam or hot water escape uncontrolled, pose an environmental hazard in geothermal operations. Once a blowout occurs, it may present control problems because of the difficulty of handling escaping hot fluid; however, unlike similar problems encountered with oil and gas wells, there is essentially no fire hazard. Using modern drilling techniques, blowouts are expected to be infrequent mishaps.

The potential adverse environmental effects of accidental releases of geothermal fluids include waste of the resource, noise nuisance, air contamination from gaseous emissions, pollution of surface and ground water resources, and hazard to health and safety (bodily injury to workers, both at the initial event, which may be sudden and violent, and in subsequent control attempts). These impacts are considered further in the following sections and as appropriate for the three specific areas proposed for leasing (Vol. II).

Because of the lack of knowledge of the subsurface geologic and thermal conditions, the possibility of mishaps appears somewhat greater in the test drilling stage than in following stages. Blowouts could occur throughout all succeeding stages of active geothermal operations and also at abandoned or suspended operations. Blowouts can occur during drilling operations, at wells which are undergoing production testing or have been tested, and at wells which have been in service for some time.

In addition to the blowouts in the immediate vicinity of wells, steam and hot water can issue from the ground surface in a developed or prospective geothermal field, in association with, but some distance away from a well that is experiencing difficulties. Cratering and mud

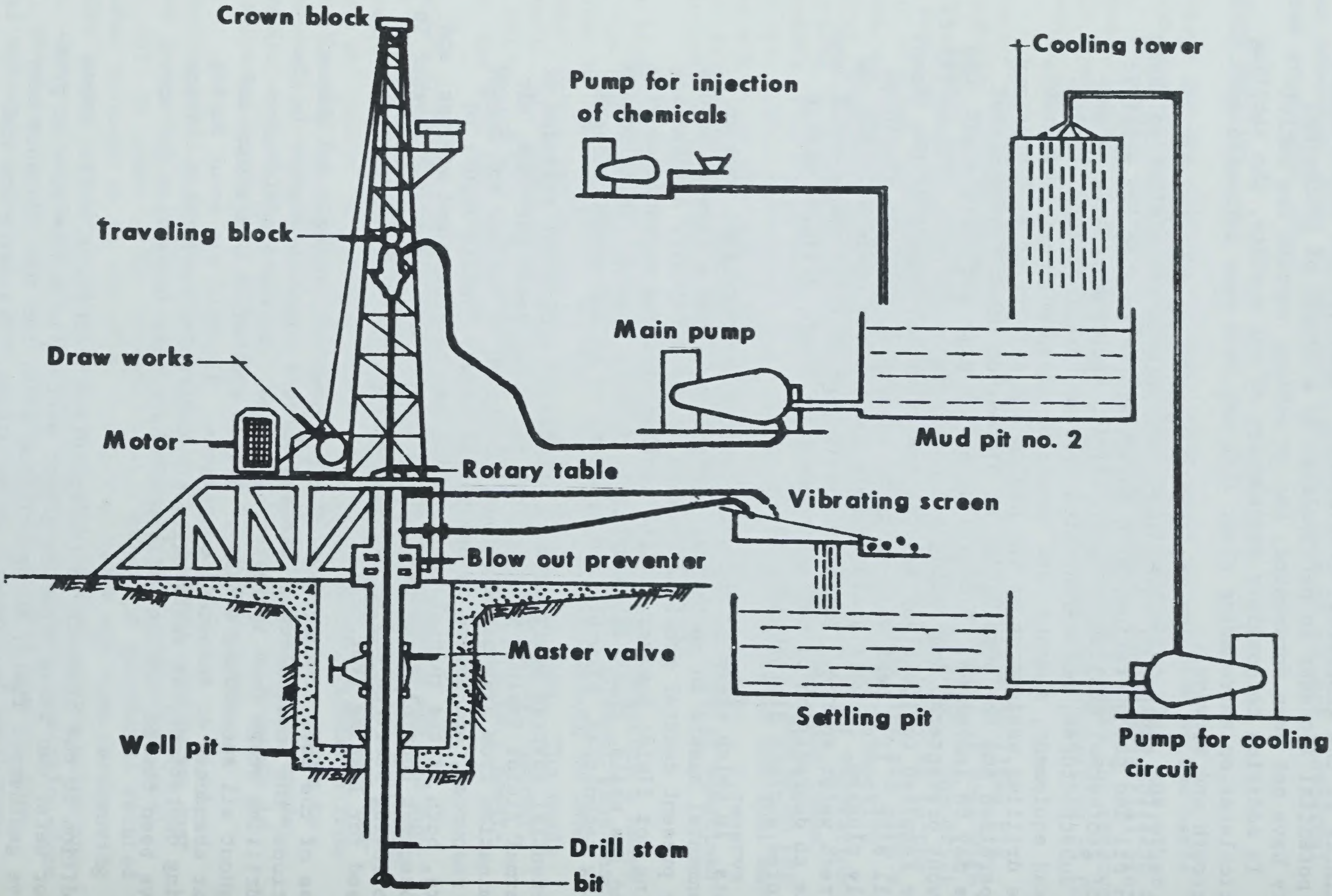


Figure III-1. Diagram of typical drilling arrangement in geothermal development.

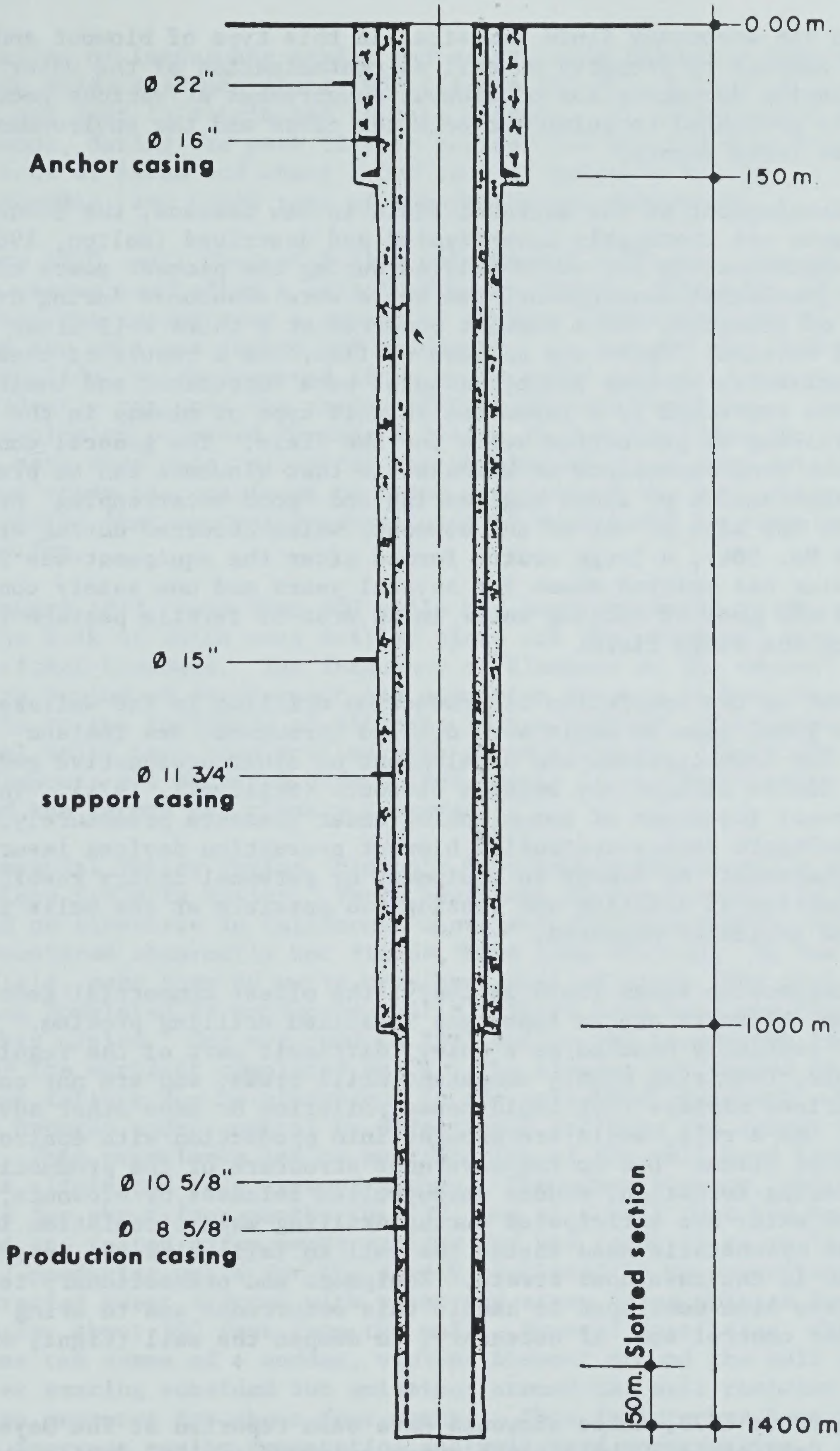


Figure III-2. Profile of typical geothermal well completion at Cerro Prieto, Mexico, showing three casings encased in cement with slotted liner for producing hot water on bottom

ejection can accompany fluid emissions in this type of blowout and may lead to damages to property as well as contamination of the water regime. The following documentation of blowout occurrences at various geothermal fields is presented to point out both the cause and the environmental impact of these events.

In the development of the Wairakei field in New Zealand, the occurrence of blowouts was thoroughly investigated and described (Bolton, 1964). Of the approximately 100 wells drilled during the pioneer years of New Zealand geothermal development, two wells were abandoned during drilling because of blowouts, and a blowout occurred at a third well after some years of service. There was no loss of life. As a result of these and other incidents, various safety measures were introduced and their success is reflected by a reduction in this type of mishap in the subsequent drilling of production wells for the field. The general conclusion drawn from experience at Wairakei is that blowouts can be prevented by the application of sound engineering and "good housekeeping" principles. At the site of one of the blowouts which occurred during drilling of (Bore No. 204), a large crater formed after the equipment was removed. This crater has emitted steam for several years and now safely contains a fenced-off pool of boiling water in an area of fertile pasture land bordering the steam field.

Subsequent to the completion of production drilling in the Wairakei field in 1964, some 78 wells were drilled throughout New Zealand chiefly for investigation and development of other prospective geothermal fields without any notable blowouts (Stillwell, 1971). There were several instances of bores coming under pressure prematurely, but use of multiple remote-controlled blowout prevention devices insured full protection. No damage to equipment or personal injury resulted and resumption of drilling and testing was possible at the wells in which the incidents occurred.

At the Larderello steam field in Italy, the oldest commercial geothermal operation, blowouts are an important localized drilling problem. Blowouts are routinely handled as a noisy, difficult part of the regular operations, requiring highly competent drill crews, and are not considered serious mishaps that could cause pollution or have other adverse effects. As a rule, wells are brought into production with controlled releases of steam. Due to the cavernous structure of the productive steam-bearing formation, sudden uncontrolled releases or blowouts, of steam and water are anticipated during drilling when circulation losses cause the hydrostatic head inside the well to fall below the pressure of the steam in the cavernous strata. Equipment and precautionary techniques have been developed to handle this occurrence and to bring the well under control and, if necessary, to deepen the well (Cigni, et al, 1971).

As of February 1973, three blowouts have been reported at The Geysers field in California. The first blowout occurred in 1957 during the drilling of well Thermal 4. This blowout, which has been attributed to

a combination of inadequate casing and minor landsliding, has been a continuing noisy nuisance since 1957 (Figure III-3). A loss of $125,000 per year is attributed to this wastage. It is estimated that this blowout, during the past 15-year period, has emitted more than 9 million tons of steam and about 4,000 tons of hydrogen sulfide, 5,000 tons of ammonia, and 6,000 tons of methane to the atmosphere.

In January 1970, well Thermal 5 blew out through a fissure some 65 feet from the casing head after a period of heavy rains. Injection of cement slurry into the casing over a period of 10 days controlled the flow of steam and the well was sealed and abandoned. On January 17, 1973 a minor landslide, which occurred after an extended period of heavy rainfall, evidently ruptured the casing of Magna-Thermal well Happy Jack 7. A steam explosion occurred forming a crater 50 feet in diameter. Several attempts have been made to control the venting of steam from outside the casing but steam has continued to issue from around the well casing. It is anticipated that control measures will be successful in stopping this steam venting.

As of January 1973, more than 100 wells had been completed in The Geysers field, the bulk of which were drilled since the 1957 blowout, with two additional blowouts. The frequency of blowouts at The Geysers during the entire period of development and operation appears to have been comparable to the incidence of blowouts in New Zealand, where about 175 geothermal wells have been drilled with three blowouts. There, the more severe blowouts all occurred before 1960, early in the development program, and the record has clearly improved.

In the Imperial Valley region, blowouts have been experienced in the Cerro Prieto field in Mexico. There have been no blowouts in the Salton Sea field or elsewhere in California where about 20 deep wells, which have encountered abnormally hot fluids, have been drilled. In the Cerro Prieto field, more than 40 wells have been drilled since 1960 with about half being completed as productive wells. There have been two blowouts during this period. One occurred in 1961 during the production testing of one of the earliest completed wells. The blowout was caused by mechanical failure due to vibrations in the well-head equipment. This well was brought under control by directional drilling and cement injection. This experience led to modification of the well-head layout, which has eliminated this type of mishap. The other blowout, which blew wild for about four months in 1972, was at a well that had been completed and tested a few years earlier and was ready to go on line as one of 17 producing wells for the nearly completed 75 MW powerplant. The protracted event started with water and steam being emitted from a large crater about 300 feet from the well. Several days later, this crater was the scene of a sudden, violent blowout around the well head. The crater venting subsided but emissions around the well resisted corrective measures for about four months. This failure has been attributed to improper casing cementation and well-head construction. Information on this recent accident is not adequate to assess the effect on the environment, but waste of the resource, damage to equipment in the

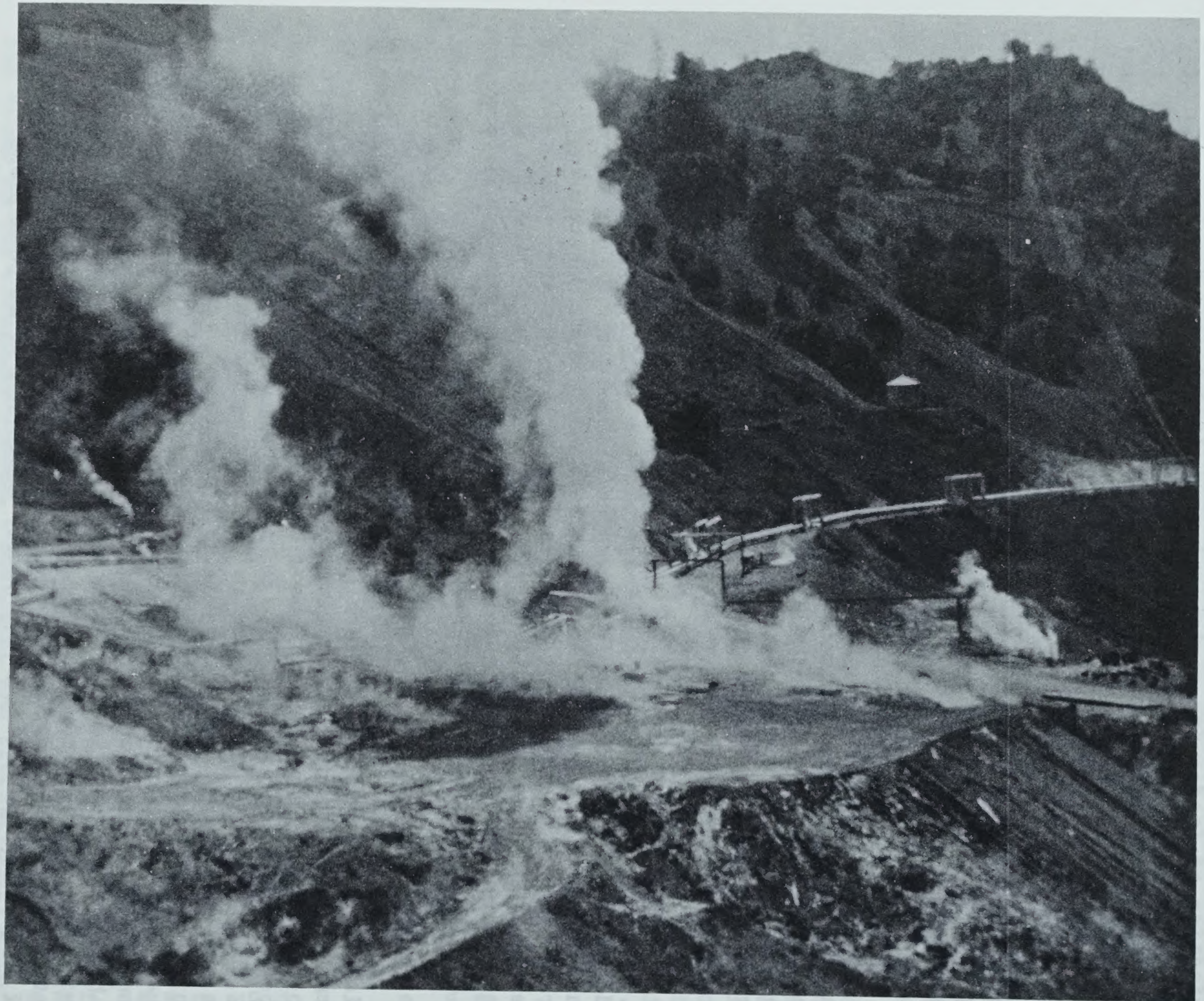


Figure III-3. Uncontrolled discharge of steam from well that blew out at The Geysers field in 1957. Steam issues at high velocity from pipe in center and seeps out of surrounding fill.

well-head vicinity, and interference with the field development work appear to have been the major effects.

In the western United States, (exclusive of The Geysers and the Imperial Valley regions and the Klamath Falls area in Oregon, where more than 350 hot-water wells have been drilled for heating and domestic use) over 32 localities had been explored for geothermal fluids by drilling 139 wells as of October 1969, (Koenig, 1971). At 23 of these localities, 124 wells encountered fluids that were heated above boiling temperature. Some geysering occurred at a few sites in California and Oregon, and even though much of the work was done with minimal regulation and background of experience, steam and water releases that could not be controlled were not a problem. However, a mishap at the site of drilling at Beowawe in north-central Nevada a year ago is an example of another set of of conditions for blowouts. In this instance, which occurred in August 1972, three of 11 capped wells that had been drilled in a suspended geothermal prospecting venture on private lands between 1959 and 1965 appear to have been dynamited by persons unknown. This resulted in strong ejections of steam and water, which were still vigorously blowing uncontrolled in mid-September 1972 (Figure III-4). Wastage of the heat resource appears to be the only significant impact as the water that is being emitted is of fairly low salinity and is used for pasture irrigation.

Although blowouts can be expected to occur, the probability of a significant blowout at any particular location can be greatly reduced as a result of technological refinements, drilling control measures, and increased operating experience.

4. Production Testing

Production testing is the transitional phase between exploration and potential development and production of a geothermal reservoir. A well that has penetrated a potentially productive geothermal zone is completed and tested over a period of time to clean out the well and to determine the flow rate, composition and temperature of fluids and gases, recharge characteristics, pressures, compressibility, and other physical properties of the reservoir fluids. Testing requires that the maximim production rate of the well be established by various controlled production rates over sufficient time to establish the hydrodynamic properties and/or boundary characteristics of the reservoir. This process involves venting of the well to the atmosphere with accompanying vapor release and noise.

Noncondensible gases such as carbon dioxide, methane, hydrogen, nitrogen, argon, carbon monoxide, hydrogen sulfide, radon, ammonia, and vapors such as boric acid and mercury are often associated, in varying amounts, with steam from geothermal sources. These gases and vapors make up generally less than 3 percent of the total steam fraction. Examples of the distribution of various gases and vapors in the steam fraction from several operating geothermal fields is presented in Table III-1.

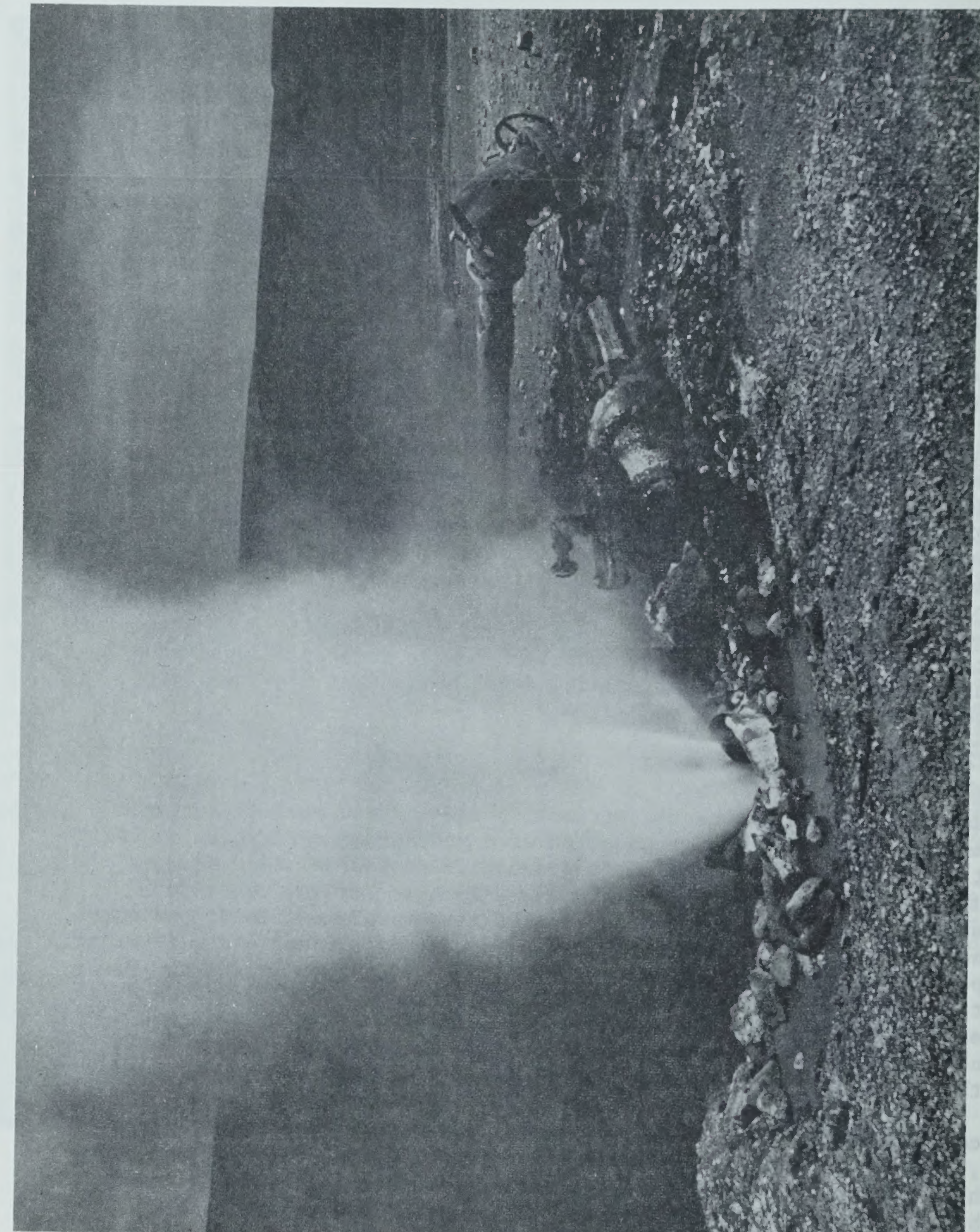


Figure III-4. Dynamited well head at Beowawe field, north-central Nevada.

Table III-1. Examples of gases associated with various geothermal systems in volume percent

	Geysers 1/ California	Larderello 1/ Italy	Matsukawa 2/ Japan	Namafjall 3/ Iceland
H_2O	98.045	98.08	99.87	99.43
CO_2	1.242	1.786	0.18	0.18
H_2	0.287	0.037	0.01	0.19
CH_4	0.299			0.01
N_2	0.069	0.0105		0.05
A			0.03	
H_2S	0.033	0.049		0.14
NH_3	0.025	0.033		
H_3PO_4	0.0018	0.0075		

1/ "Vapor-Dominated Hydrothermal Systems Compared With Hot-Water Systems," by D. White, L.P.J. Muffler, A. Truesdell

2/ "The Geological Environment of Matsukawa Geothermal Area, Japan," by H. Nakamura, K. Sumi, K. Katagiri, T. Iwata

3/ Calculated from "The Use of Natural Steam in Diatomite Plant," by B. Lindal.

Although present in small percentages, some of the noncondensible gases and vapors may pose possible pollution and health hazards. Bleeding and venting of steam wells will introduce these gases and vapors into the atmosphere during and after the production testing phase. Noncondensible gases also are vented to the atmosphere during power generation from the gas ejector vents on the condensers and from the cooling towers. Release of such gases can affect air quality in the vicinity of the powerplant and, if noxious gases are present in sufficient concentrations, may pose a health hazard to employees at the plant. The noxious gases which may be present and their levels of toxicity are presented in Table III-2. Some noncondensible gases, when mixed with oxygen from the cooling water in the condensers may be explosive if present in sufficient quantity.

From analyses of gases associated with various geothermal systems shown on Table III-1, and from their toxic levels (Table III-2), it is evident that hydrogen sulfide ranks number 1 as the most prominent potential environmental hazard, being 16 times the toxic level in undiluted geothermal steam at The Geysers and 25 times the toxic level in undiluted steam at Larderello, Italy. Sulphur compounds normally are present in the atmosphere in variable quantities, and always are considered contaminents, rather than normal constituants. Both H_2S and its oxidation (SO_2 and SO_3) are temporary constituents in air; however, they are all readily soluble in water and are washed out by rain. Both SO_2 and SO_3 react with water to form acid solutions and somewhat corrosive raindrops. Because this follows mixing of the steam with air, and oxidation reactions stimulated by sunlight, any acid rain would be very weak and far downwind of the geothermal source. Measurements in England over long periods of time have shown that the equivalent of over 17 pounds of SO_3 are annually precipitated on each acre of land from uncontaminated atmosphere.

A much greater hazard would be both the toxicity and nuisance odor of H_2S which is detectable in concentrations as small as .025 ppm by its odor of rotten eggs. Normally H_2S would mix with the atmosphere, and would not tend to accumulate locally even though it is slightly heavier than air. During stagnant air and air inversion conditions, H_2S could accumulate locally from a geothermal operation to a high nuisance level, and perhaps a mildly toxic level.

On the basis of volume percent in undisturbed geothermal steam, ammonia (NH_3) would appear to present the second greatest hazard, being 5 times the toxic level in steam at The Geysers and over 6 times the toxic level in steam at Larderello. Ammonia, however, is lighter than air and is not concentrated locally. Ammonia is readily soluble in water (as in airborne water droplets) forming ammonium hydroxide (NH_4OH). It is therefore rapidly returned to earth as rainfall where it readily is combined with soil materials and plant acids, which are beneficial as natural fertilizer.

Table III-2. Toxicity of noxious gasses and materials which may be associated with geothermal steam

AMMONIA (NH_3)

<u>Toxic level</u> - 50 ppm--.005% volume

<u>Odor and characteristics</u> - Pungent

<u>Absorption exposure</u> - Inhalation

<u>Signs and symptions</u> - Irritation and burns of skin, mucous membranes; headache, salivation, nausea and vomiting; dyspnea and cough, bronchitis and hemoptysis; pulmonary edema, ulceration of conjunctiva and cornea, corneal and lenticular opacities.

<u>Treatment</u> - Wash contaminated areas of body with soap and water; use oxygen with intermittent positive pressure breathing apparatus; bronchodialators and decongestants; codeine for cough; sedation if necessary; cortisone. Irrigate eyes with water, then instill olive oil.

<u>Disability</u> - Usually not more than 72 hours; damage to eyes may be permanent.

<u>Preventive measures</u> - Adequate ventilation; individuals with eye and pulmonary diseases should not be exposed.

BORIC ACID (H_3BO_3)

<u>Toxic level</u> - None established.

<u>Odor and characteristics</u> - White crystals.

<u>Absorption exposure</u> - Ingestion percutaneous if skin is damaged.

<u>Signs and symptoms</u> - Irritant, depressant for central nervous system; nausea, abdominal pain, diarrhea, weakness, fever, restlessness.

<u>Treatment</u> - Wash contaminated areas with soap and water; irrigate eyes with water; gastric lavage if ingested, followed by demulcents.

<u>Disability</u> - No permanent effects reported; no industrial disability reported.

<u>Preventive measures</u> - Personal cleanliness.

CARBON DIOXIDE (CO_2)

<u>Toxic level</u> - 5000 ppm of air (.5% volume).

<u>Odor and characteristics</u> - Odorless, heavier than air, collects in depressions.

Table III-2 (continued)

Absorption exposure - Inhalation.

Signs and symptoms - Stimulant for central nervous system; headache, dizziness, increased respiratory rate, drowsiness and unconsciousness.

Treatment - Oxygen and artificial respiration.

Disability - No permanent effects reported.

Preventive measures - Adequate ventilation.

CARBON MONOXIDE (CO)

Toxic level - 100 ppm (.010% volume).

Odor and characteristics - Odorless.

Absorption exposure - Inhalation.

Pathology - forms carboxyhemoglobin in blood and thus tissue anoxia.

Signs and symptons - Carboxyhemoglobin below 10%: None. Carboxyhemoglobin 10-30%: headache, drowsiness, faintness, nausea and vomiting, increased respiratory rate, increased pulse rate. Carboxyhemoglobin 30-40%: all same symptoms, plus dimness of vision, decreased blood pressure, muscular incoordination. Carbohyhemoglobin 40-60%; Carboxyhemoglobin 60% and over: unconsciousness, convulsions, death.

Effect	Subject	Single Concentration	Average Concentration	Time of Average
Epidemiological significance	human	30 ppm		8 hours
Discomfort	human	900 ppm	900 ppm	1 hour
	human	100 ppm	100 ppm	9 hours
Severe distress	human	100 ppm	100 ppm	15 hours
Lethal	human	4000 ppm		less than 1 hour

Treatment - Oxygen and artificial respiration. Symptomatic and supportive; watchfull observation for 24 hours of all patients that have been unconsciouss.

Disability - Bronchopneumonia may follow severe intoxication; disorientation, loss of memory and emotional instability may persist for several weeks. Permanent disability is rare and has not been reported in patients that were unconscious for less than three hours.

Table III-2 (continued)

Preventive measures - Adequate ventilation; chemical cartridge or airline respirator; periodic examinations of atmosphere where carbon monoxide is known to exist.

HYDROGEN SULFIDE (H_2S)

Toxic level - 20 ppm of air - .002% volume.

Ordor and characteristics - Rotten eggs, flammable; detectable in concentrations of .025 ppm by odor.

Absorption - Inhalation

Signs and symptoms - Pathology: irritant, respiratory paralysis. Local: conjunctivitis and keratitis--"spimmer's eye" skin burns. Respiratory: rhinitis and olfactory fatigue, pharyngitis, bhronchitis, pneumonia, pulmonary edema (may be delayed several days). Systemic: headache, dizziness, anoxeria, nausea, vomiting, diarrhea, irritability and insomnia, ataxia and hyperreflexia, tremors and numbness of extremities, convulsions, unconsciousness and shock.

Effect	Subject	Single Concentration	Average Concentration	Time of Average	Other
Odor	man	0.025 ppm	0.3 ppm		
Central nervous system	man		0.1 ppm	1 hour	
Pulmonary function	man		250-600 ppm		Prolong exposur
Mucosa	man	50-300 ppm			
Pathological	man		100 ppm	2-15 minutes	loss of smell
Lethal	man	400-700 ppm		½-1 hour	
Plants	Markings occur between the veining network on broad-leaved weeds. On narrow-leaved weeds a general powdery appearance of the leaf occurs between the tip and the bend. The color of the markings is usually white to tan. The youngest leaves always show the greatest amount of marking. Very often the growing point is killed.				

Treatment - Irrigate eyes with water, then instill olive oil. Wash contaminated areas of body with soap and water. Give oxygen and artificial respiration; sedation, but avoid respiratory depressants; symptomatic and supportive.

Disability - Usually not more than several days. Cerebral damage can be permanent.

Preventive measures - Adequate ventilation, chemical goggles, chemical cartridge respirator, rubber gloves. Preclude from exposure those individuals with diseases of respiratory tract and central nervous system.

MERCURY

Toxic level - 0.1 mg/cu m of air; 12.2 ppb.

Apsorbtion - Inhalation, ingestion, percutaneous.

Signs and symptoms - Pathology: Inhibition of cellular enzymes via combination with sylfhydryl groups. Necrosis of gastrointestinal mucosa. Necrosis of glomeruli and tubules. Cloudy swelling of liver. Erosive bronchitis and pneumonitis. Cerebral and cerebellar atrophy. Acute Ingestion: Burning in mouth and throat, thirst, shock, cardiac arrhythmias, nausea, vomiting, abdominal pain, bloddy diarrhea, oliguria, hematuria, albuminuria casts. Inhalation: Stomatitis, salivation, metallic taste, abdominal cramps and diarrhea, dyspnea, cough, fever, restlesness, bronchitis and pneumonitis. Chronic: Central nervous system: Headache, vertigo, vasomotor disturbances, restlessness and irritability, insomnia, peripheral neuritis, ataxia, increase in deep tendon reflexes, tremors: Static, intention, gross. Gastrointestinal: Increased salivation, stomatitis, gingivitis with blue line, anorexia, nausea, vomiting, diarrhea, occasionally damage to liver. Chronic Genitourinary: Proteinuria, hematuria, anuria. Respiratory: Rhinitis, anosmia, cough, fever.

Effect	Subject	Average Concentration	Time of Average
Severe distress	rabbit	28.6 mg/m^3	4 hours
Acute illness	man	1.2-8.5 mg/m^3	

Disability - The more severe the intoxication, the greater the likelihood of permanent impairment.

Preventive Measures - Adequate ventilation. Air must be sampled frequently if high levels of mercury are present. Physical examinations of exposed personnel at intervals determined by the degree of exposure to include determinations of mercury in urine as well as neurologic evaluations. Preclude from exposure those individuals with diseases of liver, kidneys, lungs and nerves.

Table III-2 (continued)

METHANE (Marsh gas) (CH_4)

Toxic level - 10,000 ppm of air (suggested).

Odor and characteristics - Colorless, gaseous hydrocarbon.

Absorption - Inhalation.

Signs and symptoms - Dyspnea, unconsciousness.

Treatment - Oxygen and respiration.

Disability - no permanent effects reported.

Preventive measures - Adequate ventilation, airline respirator, if necessary.

Source: Handbook of Industrial Toxicology; Handbook of Analytical Toxicology.

Carbon dioxide in undiluted geothermal steam is present in quantities of over twice its toxic level. The normal atmospheric concentration of CO_2 is about 300 ppm, and because of its greater density than air it will accumulate in terrain depressions. Normally, CO_2 in geothermal steam would not present a danger, as the noncondensable gas fraction vented into the atmosphere would act as a single gas and component separation would not take place. Adequate ventilation will prevent any danger from this gas.

Methane (CH_4) is a natural product of organic decay. It is present at about one fifth the toxic level in The Geysers steam and normally could not collect to toxic concentrations, since it is lighter than air. Although methane is a fairly stable molecule it is oxidized in the upper atmosphere to carbon dioxide and water, and thus normally would present no health and safety hazard.

Boric acid is present throughout the natural environment and comprises about .026% of the volume of sea water, a slightly higher concentration than boric acid in the geothermal steam at The Geysers, but less than that found in the steam at Larderello, Italy. Boric acid is found in higher concentrations in some hot springs and has been extracted commercially from hot springs in Italy and other areas. Boric acid or related compounds of boron are extracted commercially from bedded arid lake deposits, and from saline lake brines in San Bernadino County, California. It is doubtful that this compound would present a health or safety problem at a geothermal area if geothermal brines are disposed of properly.

Mercury is a known constituant of some geothermal fluids and may be present in sufficient quantities to pose a health hazard at some locations. High concentrations of mercury have been found in areas of hot springs, mud volcanoes, and in brines from a petroleum field in California (Tables III-3, III-4, III-5), although recent work by Barnes and others, (1973), has indicated that mercury deposits in northern California could not have originated by deposition of mercury from present thermal waters.

The compounds of mercury, like many other chemical compounds, are dispersed throughout rocks, soil, air, water, and living organisms by a complex system of physical, chemical, and biological controls. Mercury content of broad catagories of rocks in the earth's crust range from 10 to 20,000 ppb (parts per billion). The basic sources of mercury, igneous rocks, generally contain less than 200 ppb and average 100 ppb. Sedimentary rocks generally average less than 100 ppb of mercury and seldom exceed 200 ppb except for certain organic rich shales which may reach concentrations of 10,000 ppb and more. Soils average about 100 ppb mercury.

Because of mercury's tendency to vaporize, the atmosphere near ore deposits may contain as much as .02 mg/m^3 (2.4 ppb) mercury, however, this vapor is generally washed from the atmosphere by rain. The mercury content of rainwater averages 0.2 ppb. The mercury deposited by rain water and mercury from other sources generally is held tightly in organic and inorganic materials in the upper 2 inches of soils. Mercury apparently is

Table III-3. Mercury content of filtered water samples from various western States

Site	Mercury (ppb)*
California	
Hot Spring on Little Hot Creek, Long Valley NW 1/4 Sec. 13, T. 3S, R. 28E	< 0.1
Magma-Ritchie Well No. 5, Long Valley NW 1/4 Sec. 32, T. 3S, R. 28E	0.1
Hot Spring, Long Valley NE 1/4 Sec. 31, T. 3S, R. 29E	0.1
Big Springs, Long Valley NW 1/4 Sec. 25, T. 2S, R. 27E	< 0.1
Hot Spring, Long Valley S Center 1/4 Sec. 21, T. 3S, R. 29E	< 0.1
Hot Spring, Long Valley E Center 1/4 Sec. 28, T. 3S, R. 29E	< 0.1
Artesian Well, Long Valley NW 1/4 Sec. 13, T. 3S, R. 29E	0.1
Hot Spring, Long Valley S Center 1/4 Sec. 34, T. 3S, R. 29E	< 0.1
Hot Spring N. of Fish Hatchery NW 1/4 Sec. 35, T. 3S, R. 28E	0.3
Nevada	
Bog Ranch Hot Spring NW 1/4 Sec. 18, T. 46N, R. 28E	0.1
Dyke Hot Spring SE 1/4 Sec. 25, T. 43N, R. 30E	0.8
Well near Baltazor Hot Spring NW 1/4 Sec. 13, T. 46N, R. 28E	1.3
Hot Spring in Golconda SE 1/4 Sec. 29, T. 36N, R. 40E	0.1
Leach Hot Spring SE 1/4 Sec. 36, T. 32N, R. 38E	0.6
Great Boiling Spring, Gerlach NW 1/4 Sec. 15, T. 32N, R. 23E	< 0.1
Geysering Well N. of Gerlach 40° 52'.N, 119° 20' W	< 0.1
Double Hot Spring NW 1/4 Sec. 4, T. 36N, R. 26E	0.4
Soldier's Meadow Sec. 23, T. 40N, R. 24E	< 0.1
Geysering Well NW end of Pyramid Lake T. 26N, R. 20E	< 0.1
West Pinto Spring T. 40N, R. 28E	0.6
East Pinto Spring, T. 40N, R. 28E	4.0
Golconda Tungsten Mine Pit NW 1/4 Sec. 1, T. 35N, R. 40E	0.8
Jersey Valley SW 1/4 Sec. 28, T. 27N, R. 40E	< 0.1
Buffalo Valley SE 1/4 Sec. 23, T. 29N, R. 41E	< 0.1
Hot Spring Point NE 1/4 Sec. 11, T. 29N, R. 48E	< 0.1
Beowawe Hot Spring SE 1/4 Sec. 8, T. 31N, R. 48E	1.7
Walti Hot Spring NW 1/4, SW 1/4, Sec. 33, T. 24N, R. 48E	< 0.1
Darrough Hot Spring Steam Well NW 1/4 Sec. 17, T. 11N, R.43E	0.1
Darrough Hot Spring NW 1/4 Sec. 17, T. 11N, R. 43E	0.4
Diana's Punch Bowl SE 1/4 Sec. 22, T. 14N, R. 47E	< 0.1
Boil in Stream near Diana's Punch Bowl SE 1/4 Sec. 22, T. 14N, R. 47E	< 0.1
Spring at base of Diana's Punch Bowl SE 1/4 Sec. 22, T. 14N, R. 47E	< 0.1
Potts Ranch Hot Spring NE 1/4 Sec. 2, T. 14N, R. 47E	< 0.1
Lee Hot Spring NE 1/4 Sec. 34, T. 16N, R. 29E	< 0.1

Table III-3. (continued)

Site	Mercury (ppb)*
Oregon	
Barry Ranch Hot Spring SE 1/4 Sec. 27, T. 39S, R. 20E	1.7
Fisher Hot Spring NW 1/4 Sec. 10, T. 38S, R. 45E	0.1
Crump Spring Sec. 27, T. 38S, R. 24E	0.4
Hunter's Hot Spring Sec. 4, T. 39S, R. 20E	0.3
Belknap Spring NE 1/4 Sec. 11, T. 16S, R. 6E	0.1
Breitenbush Hot Spring Sec. 20, T. 9S, R. 7E	0.2
Austin Hot Spring Sec. 30, T. 6S, R. 7E	0.2
Weberg Spring Sec. 18, T. 26E, R. 18S	0.3
Crane Hot Spring SW 1/4 Sec. 34, T. 24S, R. 33E	0.5
Unnamed Hot Spring, Harney Co. , Sec. 36, T. 27S, R. 29 1/2 E	0.1
Hot Spring N. of McDermitt Drv. 35, T. 40S, R. 42E	0.1
Mitchell Butte Hot Spring NE 1/4 Sec. 12, T. 21S, R. 45E	0.1
Neal Hot Springs NW 1/4 Sec. 9, T. 18S, R. 43E	0.1
Radium Hot Spring Sec. 28, T. 7S, R. 30E	0.5
Hot Lake Sec. 5, T. 4S, R. 39E	3.2
Lehman's Hot Spring Sec. 1, T. 5S, R. 33E	0.3
Blue Mt. Hot Spring Sec. 13, T. 14S, R. 34E	0.4
Beulah Hot Spring SE 1/4 Sec. 2, T. 19S, R. 37E	0.1
Spring S. of Riverside, Ore. Sec. 20, T. 24S, R. 37E	0.1
Mickey's Hot Spring Sec. 13, T. 33S, R. 35E	0.1
Alvord Hot Spring Sec. 33, T. 34S, R. 34E	<0.1
Hot Spring (Lake) S. of Alvord Lake Sec. 15, T. 37S, R. 33E	0.4
Idaho	
Bridge Hot Spring NW 1/4 Sec. 23, T. 15S, R. 26E	<0.1
Hot Well near Bridge, Idaho SE 1/4 Sec. 23, T. 15S, R. 26E	<0.1

*(ppb) parts per billion

Source: U.S. Geological Survey

Table III-4. Mercury analyses of selected thermal and mineral waters and their deposits, Northern California mercury district

[Detection limit, 0.01 part per billion. N.d., not detected. Analyses by M.E. Hinkle]

Sample	County	Mercury concentration (in ppb)
Condensates, condenser coil packed in ice		
McKinley well 1	Lake	3.0
McKinley well 3	--do	1.0
Waters of low to moderate salinity, T < 40°C		
Allen Spring	Lake	N.d.
Bartlet Spring	--do	N.d.
Spring east of Alice mine	Colusa	N.d.
Waters of high salinity, T < 40°C		
Grizzly Spring	Lake	N.d.
Abbott Mine water	--do	1.0
Dead Shot Spring	Colusa	N.d.
Wilbur oil test well	--do	0.2
Salt spring north of Wilbur Springs	--do	.1
Complexion Spring	Lake	1.5
Salt Spring north of Stonyford	Glenn	N.d.
Redeye Spring (Fouts Springs)	Colusa	N.d.
Waters of low salinity, T > 40°C		
Castle Rock Spring	Lake	N.d.
Anderson Spring	--do	N.d.
Seigler Spring	--do	N.d.
Waters of moderate to high salinity, T > 40°C		
Sulfur Bank	Lake	1.5
Wilbur Springs	Colusa	1.5
Solids		
Sulfur floating on Wilbur Springs	Colusa	30,000
Magnesia-silica gel from Complexion Spring	Lake	800
Silica-magnesia gel from Aqua de Ney	Siskiyou	500

Mercury in the Environment, U.S. Geological Survey Professional Paper 713, 1970

Table III-5. Mercury concentrations in thermal waters from Yellowstone National Park

[Detection limit, 0.01 part per billion; N.d., not detected. Analyses by M. E. Hinkle)

Sample	Location	Mercury concentration (in ppb)
Ojo Caliente	Midway Basin	0.14
Ear Spring	--do	.22
Bonita Spring	--do	.07
Chinaman Spring	--do	.10
Steady Geyser	Lower Basin	.07
Snort Spring	Porcupine Hills	.10
Beryl Spring	Gibbon Canyon	.18
Little Whirligig Spring	Norris Basin	.07
Cinder Pool	--do	.28
Spring, base of Porcelain Terrace	--do	.10
Echinus Geyser	--do	.11
Cistern Spring	--do	.08
Primrose Spring	Sylvan Spring area	.31
Sulfur Pool	--do	.27
Green Spring	--do	.20
Blue Spring	--do	.20
New Highland Terrace	Mammoth Spring	.05

Mercury concentrations from analyses of petroleum from the Wilbur Springs area, Northern California

[Detection limit, 0.01 part per billion. Analyses by M.E. Hinkle]

Sample	County	Mercury concentration (in ppb)
Tarry petroleum, Abbott mine	Lake	500,000
Petroleum, Wilbur oil test well	Colusa	1,000

Mercury in the Environment, U.S. Geological Survey Professional Paper 713, 1970

removed from surface waters in large part by absorption on clays and on hydrous oxides of iron and manganese, and also by algae and plankton. Also, the presence of sulfide and reducing conditions will concentrate mercury in the sediments.

Higher concentrations of mercury are likely to occur in underground waters because of longer and more intimate contact of water with mineral grains, and other factors. Limited sampling of oil field brines and petroleum from California (Table III-5) showed them to contain from 1,000 to 500,000 ppb mercury. Hot springs (Tables III-3, III-4, III-5) range generally from undetectable levels of mercury to 3.2 ppb, however, one measurement of 20 ppb has been recorded. Vapors issuing from fumeroles and steam condensates from hot springs have been shown to contain up to 130 ppb mercury. Condensable steam from the McKinley steam field at Castle Rock Spring, Lake County, California, near The Geysers steam field, contains from 1 to 3 ppb mercury. This is below the maximum level of mercury considered safe for drinking water which has been proposed by the U.S. Public Health Service at 5.0 ppb.

Thermal springs of Yellowstone Park (Table III-5) have low levels of mercury, yet buildups of from 5,000 to 500,000 ppb have been measured in elemental sulfur and in fine grained muds associated with springs and fumeroles in the Park. These values represent concentrations precipitated from low mercury waters by the sulfur. Sulfur precipitated from condensed steam of PG&E power plant No. 2, The Geysers, California, contained 5,000 ppb mercury. Large mercury anomalies have also been found around the Italian geothermal steam fields of Larderello and Monte Amiata where more than 50 percent of stream sediment analyses ranged from 200 to 50,000 ppb in mercury. These anomalous levels are thought to be caused by the mercury vapors in geotheraml steam, as they cannot be traced to mercury deposits.

Solute mercury introduced into the ground environment by rainfall is quickly transformed to the particulate form by reduction to metallic mercury, by sorption on to inorganic sorbates, by complexation with nonviable particulate organics and by sorption and ingestion by viable biota. Under normal conditions mercury can be present in one or more of three different oxidation states. In several of these states, bonding is stronger than solubility with water, and thus mercury that enters reduced sediments can become relatively immoble, as long as certain conditions prevail. Most mercury species are more soluble in organic solvents than in water, however, and the methyl ion, $HgCH_3^+$ has been cited as the most important form found in fish and various other food products of animal origin.

Although mercury is not considered as essential food material for organisms, methyl mercury, being soluble in water, is available for incorporation into the body tissues of organisms in the aquatic environment and secondarily into terrestrial predators, such as man. The concentration of mercury by living things may accumulate by way of the food chain, or by direct assimilation from the surrounding medium. In any event, if it accumulates in sufficient concentration in living tissue, it can become extremely

toxic (Table III-2). Aquatic organisms, as well as man, will concentrate mercury within their bodies only when the intake rate exceeds the elimination rate. This will result in a buildup with time to the extent that accumulated mercury can become toxic and, eventually, lethal (Table III-6).

The toxic effect of waterborne mercury was vividly emphasized during the early 1950's when about 50 persons of more than 100 affected in Japan died from cumulative effects of eating fish and shellfish highly contaminated by methyl mercury that had been introduced into Minamata Bay from waste effluents from a plastics factory. Mercury contamination of fish has been reported in Sweden, from Lake St. Claire in the United States, and from other areas. High mercury levels originating from natural sources have been shown in fish by analyses of specimens which were preserved before the possibility of industrial contamination.

As a result of the Japanese and other experiences, a tentative upper limit of 5.0 ppb of mercury in drinking water has been proposed by the U.S. Public Health Service. This maximum is thought to be safe for human health when total probable mercury intake rates of physiological processes, and excretion rates are taken into account. The Food and Drug Administration has declared that fish and other foods that contain more than 500 ppb mercury are unfit for human consumption.

During production testing,considerable monitoring and analytical work will be necessary and required to determine the quantity of mercury vapor and other potentially toxic substances present in geothermal fluids at each field, to evaluate the potential hazard which its presence may create, and to establish the control measures to be imposed to assure meeting environmental and public health and safety requirements.

Radium and radon are known to be associated with certain geothermal manifestations, particularly hot springs. The concentration of radium in natural waters generally is below 10^{-9} Mc/ml (micro curie per milliliter), but concentrations exceeding 9×10^{-6} Mc/ml have been reported for certain thermal springs in the United States and still higher concentrations have been reported for waters in other countries. Maximum permissible concentrations in drinking water for occupational exposure has been set by the International Commission on Radiological Protection (National Bureau of Standards, Handbook 69) as 2×10^{-7} Mc/ml. Radium precipitates from solutions under oxidizing conditions with carbonates, iron, and perhaps silicates, and if present in hot-water geothermal systems may accumulate in the scale that builds up in wells and pipelines. Ordinarily, it is very doubtful that a buildup of radium in scale would be greater than that associated with natural tufas and sinters around hot springs and geysers, however its presence in pipeline scale could concievably pose a health and safety hazard around steam transmission pipes and powerplants after several years of operation.

Radon, a gaseous radioactive decay product of uranium, has a halflife of 3.82 days and, being gaseous, will escape into the atmosphere through any natural or artificial opening. A small amount of radon would be a component of the noncondensible gas fraction of the steam; however, it

Table III-6. Lethal concentrations of mercury compounds for various aquatic organisms and man

Organism	Lethal concern ratio (ppb)	Mercury compound
Aquatic organism		
Bacteria:		
Escherichia coli------------	200	Mercuric chloride.
	200	Mercuric cyanide.
	300	Ethylmercuric bromide.
	300	Phenylmercuric chloride.
	300	Ethylmercuric oxalate.
Phytoplankton:		
Marine mixture-------------	60	Ethyl mercury phosphate.
Scenedesmus----------------	30	Mercuric chloride.
	150	Mercuric cyanide.
Protozoa:		
Microregma-----------------	150	Mercuric chloride.
	160	Mercuric cyanide.
Zooplankton:		
Daphnia pulex--------------	5	Phenyimercuric acetate.
Daphnia magna--------------	20	Mercuric cyanide.
	6	Mercuric chloride.
Amphipod:		
Marinogammarus marinus------	100	Mercuric chloride.
Isopod:		
Mesospheroma oregonensis----	15	Mercuric nitrate.
Flatworm:		
Polycelis nigra-------------	270	Mercuric chloride.
Polychaete:		
Mercierella enigmatica------	1,000	Mercuric nitrate
Mollusca:		
Bivalve larvae--------------	27	Mercuric chloride.
Australorbis glabratus------	1,000	Do.
Fish:		
Stickleback-----------------	20	Mercuric nitrate.
	4-020	Mercuric chloride.
Guppy-----------------------	20	Mercuric nitrate.
	20	Mercuric chloride.
Shiner----------------------	800	Ethyl mercury phosphate.
Eel-------------------------	27	Mercuric chloride
Channel catfish-------------	580	Phenylmercuric acetate.
	1,300	Ethyl mercury phosphate.
Rainbow trout---------------	2,000	Pyridylmercuric acetate.
	9,200	Mercuric chloride.
Salmon----------------------	20	Phenylmercuric acetate.
	50	Mercuric acetate.
Man		
Adult, death	1.0 gram	Mercuric chloride.
Adult, chronic illness	.1 gram	

Mercury in the Environment, U.S. Geological Survey Professional Paper 713, 1970.

ordinarily would pose no health and safety hazard as it would be dispersed into the atmosphere with a very short halflife. About 122 tons of radon gas escape to the atmosphere daily on a worldwide basis from natural sources, and buildups of radon gas are quite common where it becomes trapped beneath air inversion layers in the atmosphere. If inversion conditions were prevalent for an extended period of time over a geothermal area, the resultant buildup of radon gas would add only slightly to man's total radiological burden from other natural sources such as rocks and soils. However, monitoring will be required at each lease site to assure public health and safety protection.

Any accidental discharge of steam due to the rupture of pipelines or a well blowout will yield gases and vapors to the atmosphere. The quantity of noncondensible gases and vapors released by such an accident may be no greater than if the steam were passed through a powerplant and the gases released to the atmosphere through cooling towers and gas ejector vents. Gas extraction process installed at powerplants could concentrate gases and vapors which if accidentally discharged could increase the concentration of pollutants to the atmosphere.

In addition to considering the impact of each individual source of air pollution, the total impact of geothermal development on the local airshed must be evaluated. Some sources of pollution may be satisfactorily controlled voluntarily through existing technology while others may have to be subject to strict regulatory standards and control. The total air pollution load possible from geothermal development may in some cases make geothermal development incompatible with surrounding land uses, thereby precluding resource development and use in such areas.

Open burning of trash and wastes, including brush from land clearing operations, on geothermal leases could contribute pollutants and particulate matter to the atmosphere with resultant degradation of local air quality. Accidental brush or forest fires would contribute to air pollution and may endanger wildlife, structures, and human life.

The noise level for any geothermal lease area can be expected to increase as a result of the various phases of geothermal activity. Movement of trucks and other vehicles, drilling of wells, venting of steam, and other ancillary sound sources all tend to raise the background noise level. In particular, the drilling of wells with associated sounds from power sources, racking of drill pipe, and venting of compressed air and cuttings during dry drilling phases, and the venting of steam wells after completion are principal sources of noise. Excessive noise levels can pose a health and safety hazard to employees, are objectionable to residents or visitors to the area, and may disturb wildlife distribution and breeding patterns.

A simplified comparative analysis of noise levels generated at The Geysers field and from other sources is presented in Table III-7. Noise measurements from both vapor and liquid dominated geothermal fields of other countries have not been made or are not available in the literature. Noise levels for other geothermal fields may not be of a similar magnitude

Table III-7. Comparison of noise levels between The Geysers geothermal area and other noise sources

Source	Level	Distance
The Geysers area		
Drilling operation (air)	126 dB(A)	25 feet
Drilling operation (air)	55 dB(A)	1,500 feet
Muffled testing well	100 dB(A)	25 feet
Muffled testing well	65 dB(A)	1,500 feet
Steam line vent	100 dB(A)	50 feet
Steam line vent	90 dB(A)	250 feet
Comparative levels		
Jet aircraft takeoff	125 dB(A)	200 feet
Threshold of pain	120 dB(A)	
Unmuffled diesel truck	100 dB(A)	50 feet
Street corner in a large city	75 dB(A)	
Residential area at night	40 dB(A)	

dB(A) decibel value measured using the A weighting network of a standardized sound level meter.

to those at The Geysers. Measurements of noise levels will be necessary at all geothermal developments to determine the potential objectionability to residents and the health and safety danger due to noise emissions. Such measurements will provide the basis for leasing, operational, and control decisions.

Noise may have an effect on the wildlife community surrounding geothermal leases. Noise may drive some species from the area, may disturb normal predator-prey relationships, or may affect mating and rearing habits. Although it is presumed that noise may have adverse impacts on wildlife, such impacts have not been adequately documented at the present time. The influence of noise on endangered or rare species and on critical breeding or nesting grounds will be considered prior to leasing of lands for geothermal development.

Test drilling and production testing of geothermal steam resources could have varied impacts upon fish and wildlife, not all of which are completely understood. Most of these impacts would occur on or adjacent to well sites, although water quality impacts could potentially have farther-reaching influences. The magnitude of particular impacts would depend upon the extensiveness and duration of geothermal development activities and operations and the effectiveness of impact control measures.

As a specific development proceeds through test drilling and production testing, physical land modification and commotion could occur. These activities include such things as construction of roads, ponds, and drill sites and drilling of wells, which could result in loss of wildlife values, including both habitat and recreational use of wildlife within the area of influence. Such modifications would physically alter or remove existing wildlife habitat and the permanence of these effects would be dependent upon the nature of the particular construction or operational activity. However, in some instances clearings, revegetated areas and roads or trails resulting from geothermal operations could improve wildlife habitat. It also should be recognized that many animals also have the ability to adapt to changed environments. In addition to land modification, the noise and other commotion could have displacement effects upon animals and birds in the site vicinity. The degree and permanence of displacement or disturbance would depend upon the scope, duration and type of activity.

Most areas adjacent to drilling and test operations, but outside the immediate zones of physical modification and noise, would retain part or all of their fish and wildlife populations and habitat. However, where existing public access to these areas would be restricted to reduce hazards to the public, there could be an accompanying reduction of hunting, angling, camping and other recreational opportunity on these lands. The importance of these losses would depend upon the capacity of other available habitat areas to absorb the pressures which are presently absorbed by the geothermal area.

Potentially significant impacts upon fish and wildlife could result from improperly planned or executed handling of geothermal fluids. If controlled

releases, spills, seepage or well blowouts were to result in significant additions of toxic, mineralized, or saline geothermal waters to streams, ponds, game management areas, etc., adverse impacts would result. These impacts could include the alteration of fishery habitat and waterfowl nesting and feeding areas over the area of influence. If toxic substances, such as boron, sulfides, methane, flouride, selenium, and others were present in such releases, they also could exert adverse impacts. For example, the installation at The Geysers in California at one time added heated fluids, containing boron and ammonia, to Big Sulphur Creek that may have resulted in adverse impacts upon aquatic life. Releases of heated effluents to aquatic habitat could alter aquatic habitat and life, perhaps creating temperatures intolerable to existing fish species and stimulating growth of nuisance algaes.

Reinjection of geothermal fluids also possesses the potential for adverse impacts upon fish and wildlife. For example, the present major source of water for the Salton Sea in California is surface and subsurface irrigation waste water. If significant quantities of highly saline geothermal waters were added to the Sea as a result of improperly planned and applied reinjection techniques, the additions could contribute to degradation of the existing marginal water quality.

If sump ponds or other impoundments were required as part of the development, they could, depending upon site-specific circumstances, have localized and varying impacts upon fish and wildlife resources. For example, if the ponded water were free of toxic materials and disease-producing elements, benefits could occur in the form of increases in aquatic habitats and nesting and feeding areas for waterfowl and marsh birds. On the other hand, pond water exhibiting toxic concentrations of harmful substances could result in adverse effects on waterfowl.

Erosion from roads and the construction activities, if not properly conducted, could result in added siltation of aquatic habitat within the area of project influence. The siltation would be most severe during construction phases, although some might extend into the operational stages. Harmful siltation effects could include coverage of fish spawning and feeding areas and shallowing of streams. The degree of siltation damage to aquatic habitat within the area of influence would be dependent upon the success of erosion control measures.

In the event that exploratory drilling and production testing indicate that a geothermal field has economic potential for power development, a commitment must be obtained from a customer electric utility to warrant further development. This would be a major decision point in the development and production of the geothermal resource of a given area. Additional permits would be required for construction of industrial facilities and for road and powerline rights-of-way on Federal lands off of the lease site.

5. Field Development

Favorable exploration, test drilling, and production testing programs probably would lead to the drilling of a number of additional wells to develop

a field. Essentially the same types of environmental effects would be involved in the field development phase as in the preceding phases. Access roads would be improved to give permanent service. Limited service and living quarters would be constructed if required, and adequate water sources and sewage facilities would be provided.

Field development in a large field can continue for many years as new wells and additional power-generating units are developed. Since most environmental impacts can be cumulative, such as water and air pollution, proper care must be exercised at each step.

An additional health and safety hazard is introduced during field development. Asbestos, alone and in combination with fiberglass, is used as an insulating material around pipelines, as sheathing on cooling towers, and for various other uses during and after this phase of development. If concentrations of airborne asbestos fibers accumulated in enclosed fabricating or storage areas, the fibers could be inhaled by workers during fabrication, storage, or field installation, posing a health hazard.

The drilling for geothermal fluids would continue to include test wells and intensive production-testing as the limits of the field are probed. In these wells, uncertainties as to the depth of the producing zone and type of fluids to be encountered will be less than in the initial prospecting stages, but possible local water pollution by blowouts, spillages, and leaks may be greater. The bulk of this drilling would take place between proven wells under more predictable conditions so the environmental hazards should be reduced due to greater understanding of reservoir conditions.

The impact on water supply during the field development phase will be similar to that from earlier activities. However, in this phase the information derived about the site and regional geohydrology, both as to the rate and paths of recharge and natural discharge (hydrodynamics) of the geothermal reservoir, and as to the prediction of the effects of the future operational-scale extraction of the geothermal fluids is basic to estimation of reserves, the optimum rates of production, and resource conservation consideration.

If the geothermal production contains substances that are found to be detrimental if allowed to invade the environment, the contaminating substances must either be removed or otherwise disposed of before surface disposal or, on reinjection if harmful, to the subsurface. If no harmful materials are present, or if these materials can be economically removed from the fluids, it is possible that fluids produced with the energy can be produced as fresh water at a geothermal installation. Conservation and utilization of such demineralized water would be required where such production is economically feasible.

To the extent that wells produce geothermal fluids, it also may be necessary to carry out an injection well program in close coordination

with the production wells. The injection well program must be planned to avoid the degradation of ground water resources not only in the site vicinity but over the long term in the geohydrologic province, in which the site is located, which may extend for many miles beyond the lease area.

Deep well injection is the emplacement of wastes within the earth, usually below the water table and beneath a confining stratum which serves to isolate the wastes from potable water supplies or other valuable or potentially valuable resources. The feasibility of injecting liquid wastes deep within the earth is suggested by the enormous volume of subsurface fluid storage space. The earth, however, contains little empty space so waste liquids may have to be accommodated by compressing or displacing existing fluids (including injections into depleted reservoirs) or by compressing or deforming the surrounding strata. The possible adverse effects of high pressure waste injection include the displacement of saline waters distant from the injection site, the fracturing of geologic strata that could result in pollution of high quality zones, the migration of wastes and native fluids along existing or created fractures, the upward transfer of pollutants along well casings, and even the gross readjustment of the surrounding strata. The injection of fluids within the earth is concerned not only with hydrostatics but involves also the distribution of the initial pressure increases and their effects on the surrounding rock matrix. Chemically unstable wastes may produce heat and pressure after being injected, and these wastes may react with the fluids and minerals of the injection horizon, changing the permeability or strength of the surrounding strata. Determining the compatibility of the waste solution and the fluids and minerals of the injection horizon requires careful study. The identification of strata where injection may be feasible may be difficult.

Currently, there are two distinct types of deep well injection practiced in the United States. The first, and by far the largest in terms of number of wells and volume of fluids injected, is the return of brines and other fluids to the aquifers from which they were extracted. This is a common practice in the oil and gas industry, where 9,182,173 barrels per day (Petroleum Engineering, 1967) of wastes are injected through many thousands of wells in the oil-producing states. Another type of deep well injection is that involving liquid industrial (including geothermal), municipal, or low-level radioactive wastes. Currently a minor practice compared to the reinjection of brines, however, the number of industrial and municipal waste injection wells is increasing rapidly.

Brine reinjection has been practiced by the petroleum industry for over 50 years, both in waterflooding for the secondary recovery of oil and as a means of disposal of the brines associated with the production of oil. Ideally, the brines are reinjected into the strata from which they were produced, not only disposing of great volumes of liquid material but also preventing land subsidence and facilitating greater oil production. In the reinjection of oil-field brines, the most difficult problems are expected to be associated with confining the fluids to the desired strata. A great deal of exploration and documentation of the geologic

and hydrologic situation has been made and is available for areas where this type of reinjection is practiced. Wastes are not always as well confined or as accurately emplaced as desired. The major area for concern in the reinjection of brines are proper engineering safeguards. Injection wells must be constructed and operated to guarantee that the brines are entering, and being contained in, the desired strata. Generally, there has been little or no evidence of serious adverse impacts from such injections.

During the field development phase, the possibility of water pollution or possible blowouts, due to failure of casings and/or cement-jobs, exists at wells that have been completed and then shut-in before finally being connected to a powerplant. In the operational phase, difficulties of this type are often recognized from the behavior of each well and corrected before serious harm is done. However, it is also possible during this period for a casing leak or poor cementing job to go undetected and allow steam and brine to migrate into shallow aquifers. In most fields, the periodic monitoring of shut-in wells will permit problems due to leakage from casing failures to be identified. Shallow ground-water observation wells satellite to production wells or at strategic locations throughout the field could also be useful in detecting leakage and pollution of fresh water sources.

6. Powerplant and Powerline Construction

Prior to approving the construction of facilities for the actual generation and transmission of electrical power, a thorough evaluation will be made of all available information relative to the geothermal reservoir. Where such information indicates that production from the reservoir would entail unacceptable adverse environmental effects, continuance of the project would not be approved. If additional data, new technology, improved systems,etc. subsequently should be developed which would permit an environmentally safe operation, appropriate approval consideration would be given to the project at that time. The installation of power generation and transmission facilities, much of which could not be salvaged or converted to other types of power generation, involves multimillion dollar investments. Thus, it would be essential to evaluate carefully all foreseeable adverse environmental effects of the project prior to the lease sale and again before commitment of large capital expenditures and environmental resources. Such effects as potential air and water pollution, the impact on fish, wildlife, and recreation, and aesthetic degradation, would have to be re-examined. This would precede the stage where a separate permit for plant construction would be required.

Power generation and transmission facilities would be constructed in stages to establish the most efficient scope for the project in relation to the associated geothermal reservoir. Under present technology, above-ground insulated pipes are used to transport the steam from the well to the powerplant because of pronounced thermal pipeline expansion and contraction during operation (Figure III-5). An underground pipe system is not economically feasible owing to service and equipment requirements.

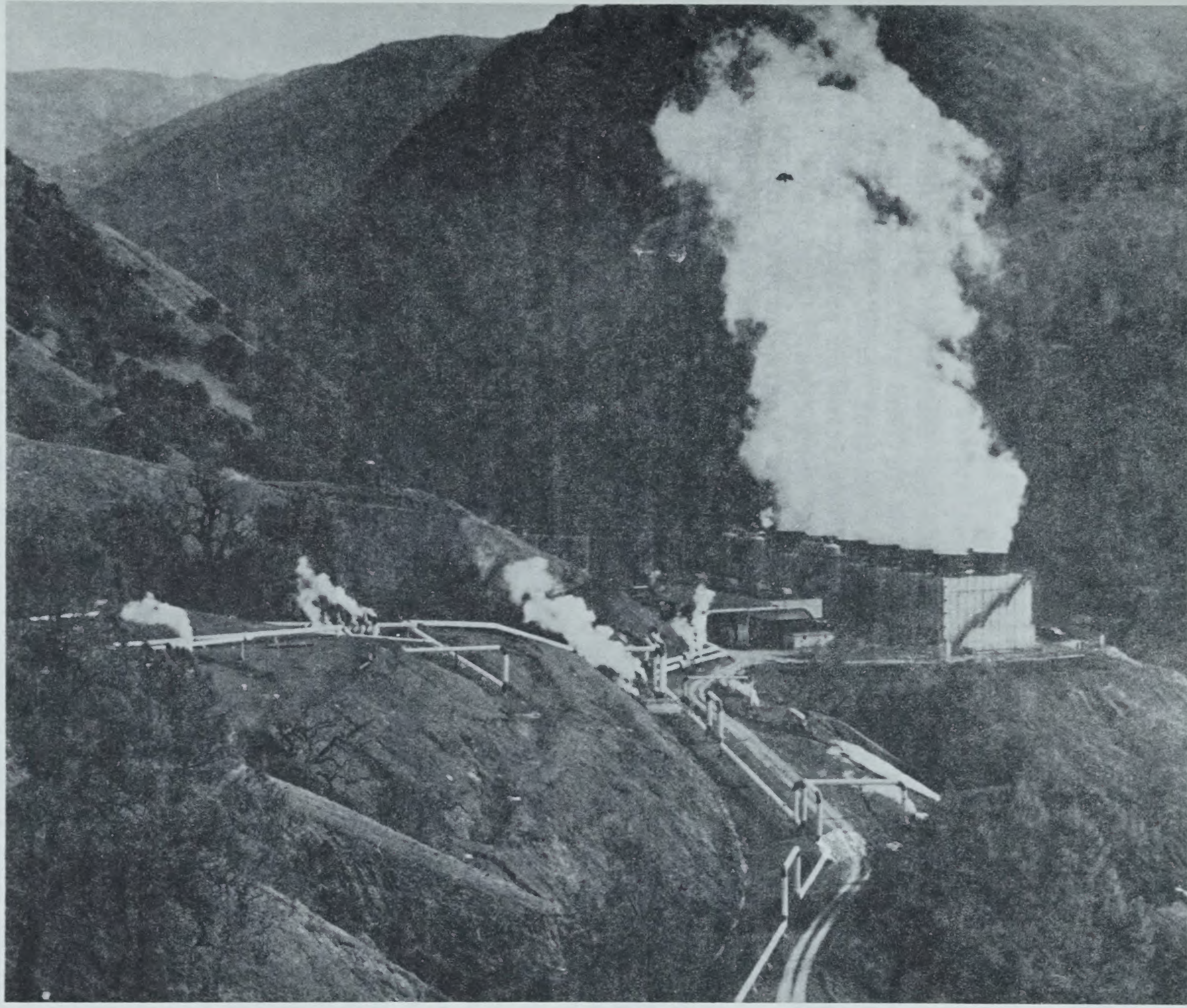


Figure III-5. PG&E units 3 and 4, shown here, went into commercial operation in 1967 and 1968, respectively. In the foreground are steam pipes with expansion loops. The steam condensate rising from the row of five low stacks at left marks the location of blowdown valves. When the plant has to be shut down, the steam excapes through these valves.

If corrosive fluids are produced by the wells, the equipment for handling such fluids, or inside surfaces of such equipment, must be made of suitable corrosion-resistant materials. This would be normal design practice to assure reasonable life for the equipment; it also is necessary to prevent leaks and spills which could result in contamination of surface waters.

Venting of steam to the atmosphere can create an adverse environmental impact as described earlier.

Construction of generation and power transmission facilities on essentially undeveloped Federal lands will involve changes in land utilization on such lands, adjacent private lands and nearby Federal lands. Similarly, the development of geothermal resources and facilities on private lands can have impacts on adjacent Federal lands and resources. Developed portions of Federal leases primarily will involve single-purpose industrial uses. Undeveloped or non-intensively used lease lands would continue to support multiple land uses, particularly values such as watershed, grazing, cultivation, wildlife habitat, etc. New access to geothermal areas not specifically restricted to protect property and public health and safety values may be expected to open additional areas for multiple use, particularly recreation.

Construction of generation and power transmission facilities can result in the alteration of aesthetic qualities by changing land use to industrial development. Changes in aesthetic quality would result from the removal of vegetation, from soil disturbance to ccommodate roads, buildings, steam wells, pipelines, and transmission lines, and from the man-made structures placed upon the site. The usual impact would occur not only at the site of the geothermal development but also on linear corridors occupied by power transmission lines.

Impacts on the aesthetic quality would begin with the construction of temporary roads into the test drilling sites and would increase as drilling operations, pipelines, power plants, and transmission lines were added. The extent of the visual impact at a given site would vary, based upon the size and extent of the development, topography, vegetative cover, techniques used to minimize the impact, and the proximity to a population center or major travel route.

The high visibility of The Geysers development in California demonstrates a degree of visual impact where little special attention has been given to aesthetic placement of buildings and transmission lines and where camoflage techniques have not been used to blend pipelines, transmission lines or buildings into the natural setting.

For Federal land geothermal developments, full consideration must be given to aesthetic design, placement of man-made structures, use of compatible colors, landscaping and vegetative restoration in order to minimize visual impacts.

Tourists may wish to see this unique power source in operation. In such instances, the quality of their recreation experience in the general area would be enhanced. If visitations should be significant, such increased use of the area could create additional impacts such as noise, dust, damage to vegetation, fire risk, and potential damage to improvements. Adequate provision would have to be made to protect public health and safety.

Since geothermal fluids and steam can be transported only a distance of about 1 mile due to pressure and temperature loss factors, powerplant installations will be relatively small, probably not exceeding 100 MW at individual sites. A typical power plant at the Geysers consists of two turbine generators housed in a single building with an adjoining structure housing cooling towers. Geyser units 3 and 4 are housed in a building 140 feet by 34 feet and 30 feet high. Adjoining is a cooling tower consisting of three 36 feet by 66 feet shells. (For additional detail see Chapter V,A. Clear-Lake Geysers Area, California). Surface steam lines of 10 to 30 inches, fiberglass and asbestos insulated pipe with characteristic large U-shaped expansion loops, connect the wells to the power plant. The greatest distance of any connected well currently is 1,200 feet in a straight line. Each plant is served by several producing wells at spacings of about 40 acres per well. Thus, in the producing area, the terrain is laced with exposed steam pipes radiating out from the power plants which in turn are connected together with high voltage transmission lines. Brush is cleared for a considerable distance from steam and power lines to minimize fire hazard and to provide access.

The clearing and grading of the powerplant site, construction of access roads or trails, installation of steam pipelines, and powerplant construction will result in vegetative and surface disturbance. Soil disturbance and movement, disposal of vegetation and construction wastes, handling of materials, equipment and supplies, etc. could result in temporary environmental impacts such as noise, dust, surface runoff, siltation, smoke, etc. However, such potentials can be recognized readily and provided for in such a manner whereby adverse effects will be held to an acceptable minimum. Good design and engineering, proper construction techniques and controls, and adequate post-construction measures such as sloping of cut banks, revegetation, surfacing or treating roads and other areas subject to heavy vehicle traffic, soil stabilization, proper drainage, etc. will be required to prevent serious longer range environmental damage from powerplant and related facilities construction.

Similarly, power line construction will involve clearing of rights-of-way, construction of temporary and permanent access routes, erection of towers and lines, etc. Potential environmental impacts involve factors such as soil movement, erosion and siltation, dust, disposal of vegetative waste, etc. Where power lines involve relatively steep slopes, the

potential of environmental damage is increased. However, measures can be taken to prevent damage during and after construction to revegetate, drain, and restore the surface.

Since each site may involve different environmental problems due to geology, soils, topography, weather, vegetative cover, fish and wildlife values, proximity to developed or populated areas, adjacent land uses or values, geothermal steam and fluid properties, etc., a thorough environmental evaluation will have to be made as a basis for designing power generation facilities, power transmission lines and related facilities to assure environmental acceptability. In the event there should be unacceptable adverse environmental impacts, continuance of the project should not be permitted unless corrective measures, improved technology or other changes will assure achievement of environmental acceptability.

7. Full-Scale Production

The adverse environmental effects of geothermal development may decline as the field comes into full-scale production. If proper environmental measures have been fully implemented during the construction phase, vegetative cover will begin to cover exposed soils where conditions are conducive to plant growth, drainage and soil erosion measures will control run-off to minimize both on and off-site damage. The physical disturbances and activities associated with construction will have ended. During the production period, activities primarily will consist of the operation and maintenance of the power plant and related facilities and the drilling, redrilling, and workover of geothermal wells to maintain production capacity. Overall activity will be considerably reduced over that required during field development and the construction of power generation, power transmission and related facilities. A state of use equilibrium will be reached which will be conducive to broader multiple land uses of the lease area, particularly uses such as wildlife habitat, grazing and agriculture. For example, the Larderello field in Italy is in an area of intensive agricultural development. Within the confine of the field there are many farms, vineyards and orchards adjacent to producing wells, pipelines and power plants.

There is a broad range of potential adverse and beneficial effects on water resources which may result from full-scale operations. Environmentally significant alterations could occur in the ground-water and surface hydrologic regimes and in the availability of water suitable for human, agricultural, and industrial needs as a result of injection or waste disposal operations. Such impacts could be felt both on the immediate leasehold and adjacent lands as well as over a much larger area. For example, a decrease in streamflow through water withdrawal for geothermal activities could adversely affect a drainage basin for a distance many miles downstream or even an entire drainage basin. Conversely, the use of electric power from a geothermal field for a desalination water project or the by-product production of fresh water may beneficially serve a community in an outlying region or in the area adjacent to the geothermal operation.

Factors influencing the potential impacts on water supply may be both natural and manmade. Natural factors are dependent upon field types, vapor-dominated or hot-water, and their geohydrologic and physiographic settings. Manmade factors include interrelated matters of reservoir engineering and power enginneering practices, and the extent to which it is economical to incorporate desalination in the operational scheme.

Wasting of geothermal effluent to a saline lake or sea in water-deficient basins or coastal plains in lieu of reinjection or use exemplifies a potential adverse impact created by natural and manmade factors on the water regime. In more humid regions with comparable terrain conditions, water is not a scarce commodity and the possibility of adverse impacts of this type would be reduced, or might be insignificant. Reinjection of geothermal effluent could alleviate subsidence and prevent pollution of surface waters. Desalination of geothermal effluent may require that alternate water sources be found for reinjection to prevent subsidence.

Inland desert basins and semiarid terrains, in contrast to upland watersheds, present greater potential for full-scale operations with minimal adverse impact on the water supply. The potential for beneficial impact through reduction of evapotranspiration losses, salvaging of saline waters, or augmentation of local and regional water supply by joint power-desalination geothermal schemes is promising. Extractions of geothermal fluids from hot water fields underlying saline lakes or dry lakebeds and bordering alkali flats or brackish marshes in amounts exceeding recharge could, due to lowering of the water table, lead to reduction of evapotranspiration losses. Unless this process was allowed to cause harmful desiccation of marshes and aquatic wildlife habitats, it would not represent a significant depletion of the water supply. The potential for supplementing or producing fresh water from geothermal fields in these inland basin settings hinges on reservoir engineering, land subsidence controls, and local and regional power and water economics. Systematic development programs must consider these factors before an evaluation of natural wastewater reclamation can be made. There also could be beneficial impacts on water supply from full-scale operation of hot water fields in desert areas.

Full-scale operations of vapor-dominated fields, because less fluids are extracted, would have less possibility of adverse impacts on water supply. The water recharge mechanism of their hydrodynamic systems is not well understood, so it is difficult to make any quantitative predictions for prospective fields. Detailed analysis of the surface and ground-water hydrology, could require years of monitoring under developmental and operational conditions to make quantitative water supply estimates. The experience in The Geysers field indicates that this impact has not been significant over the period of 12 years of operations, in which production increased from 12.5 MW to 192 MW.

In The Geysers field, about 80 percent of the steam condensate is consumed by evaporation for condenser cooling. The remaining 20 percent is reinjected as a water quality control measure into nonproductive zones of the field. Geothermal condensate use averages about 45 acre-feet per year per magawatt of plant capacity. The current Geysers plant combined

capacity of 298 MW would represent about 13,000 acre-feet of water consumption each year. Production at a 600-MW level would represent consumption of about 27,000 acre-feet per year.

Electric power generation in hot water fields presumably would require comparable amounts of water for condenser cooling. In conventional steam turbine plants, in which steam and hot water are separated, the cooling water supply would most likely come from the geothermal steam condensate. Low-quality ground water and poor quality surface waters might, however, be used. In fields where the closed binary system is to be used, nongeothermal sources of cooling water would appear most practical. In water-deficient regions this could be a significant demand against other possible beneficial uses of the water supply.

Installations on seacoasts or tidal estuaries, such as the Wairakei field in New Zealand, or on large lakes or rivers, present special conditions with regard to sources of cooling water that differ markedly from inland geothermal fields. In determining the long-term impact on water supply for geothermal operations, consumption of 45 acre-feet of water (not necessarily fresh) annually for each megawatt produced must be considered. However, in contrast to fossil fuel and nuclear electric-power generation, water consumed for cooling in geothermal operations ordinarily comes from sources which would not otherwise be beneficially used, namely, the geothermal reservoir.

The ground-water regime in the general area of a geothermal field may be altered if appropriate protection and control procedures are not employed. A fresh-water aquifer may occur above a geothermal reservoir which contains hot mineralized or saline water. Tapping the geothermal strata could result in contamination of the fresh water aquifer if one horizon were not kept isolated from the other by properly cementing the casing of either production or reinjection wells. Beginning with the early stages of a project, suitable data must be accumulated and thoroughly analyzed, to determine what steps must be taken to prevent or minimize alteration of the local ground-water regime.

Experience in petroleum production indicates that marked changes in reservoir pressure, whether due to pressure reduction from the production of fluids, or to pressure increase due to injection, may in certain types of reservoirs, especially in faulted or fractured rocks, result in instability leading to seismic activity. Such instability due to production alone has been documented in the Wilmington Oil Field, California (Poland and Davis, 1969, p. 205) and instability due to injection was documented at the Baldwin Hills Oil Field, California (Hamilton and Meehan, 1970), and in connection with injection of waste waters at the Rocky Mountain Arsenal, Colorado (Healy and others, 1970). Similar increases in seismic activity also have been noted in association with filling of large surface reservoirs with attendant change in hydrostatic head, including Lake Mead on the Colorado River and Lake Kariba in Africa (Rothe, 1969, p. 215). The role of fluid-pressure changes in triggering seismic action is not well known

but a caustive relation has been established in many areas. In general, such earthquakes have not been damaging but the potential for major seismic action cannot be ruled out. By contrast, it also is possible that such actions may relieve earth stresses which could mitigate the severity of subsequent seismic actions.

Subsidence of the ground surface over and around a geothermal reservoir can result from the withdrawal of large volumes of fluids (Poland and Davis, 1969; Hunt, 1970). Subsidence would reach a maximum rate during full-scale operations unless replacement fluid is returned to the reservoir. In some instances it may be practical to reinject the geothermal fluids after utilizing most of their heat. Studies would be required prior to approval of operating plans and operation would have to be monitored to determine the subsidence potential and its probable consequences. In many instances, it is possible that there would be no serious land use or environmental consequences if subsidence did occur.

The close association of geothermal areas throughout the world with major rift systems, zones of crustal spreading or convergence, Cenozoic volcanism, and earthquakes has been discussed in a number of papers (McKnitt, 1965; Tanrazyan, 1970; Muffler and White, 1972). A plot of the major producing geothermal areas of the world on the world seismicity map for the year 1971 shows this close association (Figure III-6). A greater detail of the tectonic setting and earthquake history of California is shown in Figure III-7. This area, containing some of the most promising geothermal areas in the United States, is part of the circum-Pacific seismic-volcanic belt and is the most seismically active region of the United States.

Microseisms associated with thermal areas have been studied as a possible technique in exploration (Ward, 1972; Lange and Westphal, 1969; Hamilton and Muffler, 1972). Research has disclosed that the earthquakes associated with geothermal areas generally occur as swarms at depths of 2 to 6 km and that, although large earthquakes may occur at distances of 10 to 15 km from geothermal areas, the earthquakes associated with the geothermal activity are usually small, with magnitudes generally below 4.5 on the Richter scale (Ward, 1972).

Changes in geyser activity have been observed following both local and distant earthquakes suggesting that regional stresses may influence geyser activity and that active faulting may be a possible mechanism for maintaining an open channel for circulation of geothermal fluids in a deep convective system (Marler, 1964; Nicholls and Rinehart, 1967).

The association of earthquakes with geothermal areas is not surprising, as active tectonism or intrusion would provide the conditions necessary for geothermal phenomena. The role of fluid pressure changes in triggering earthquakes is not as well known, but the possibility of generating earthquakes by large withdrawals or reinjections of geothermal fluids cannot be ruled out as a potential environmental impact. To date, earthquakes associated with fluid pressure changes have been small and not disastrous, and some evidence indicates that seismic activity associated with geothermal areas is a continuous process tending to relieve regional stresses, thus reducing the probability of large earthquakes.

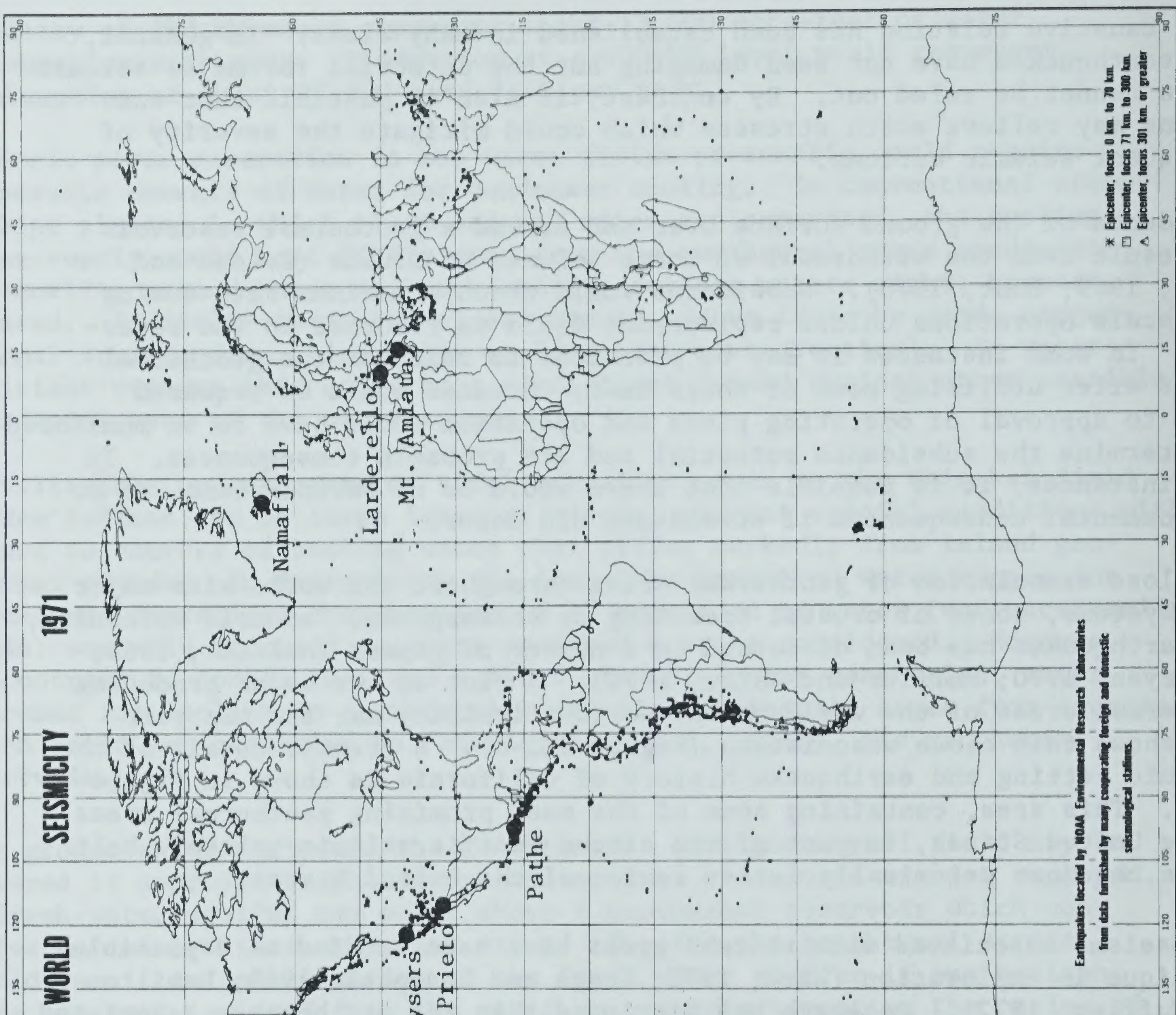


Figure III-6. Major geothermal producing areas and world seismicity for 1971.

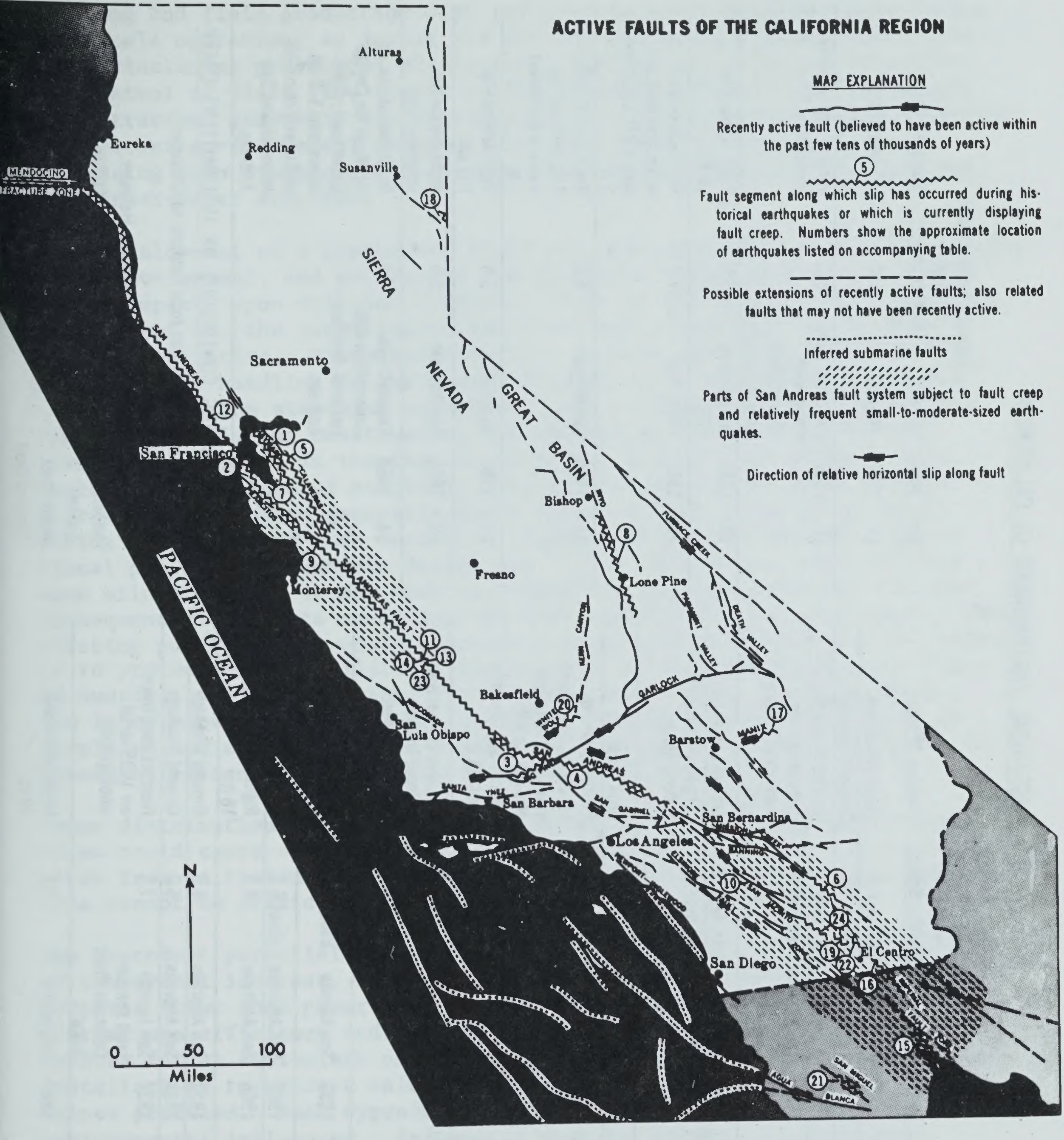


Figure III-7. Map of active faults of California showing areas of greatest earthquake activity and locations of major historic earthquakes. (See following page for details of major quakes.)

HISTORICAL EARTHQUAKES IN CALIFORNIA

No.	Date	Fault	Estimated of recorded magnitude (Richter Scale)	Surface Effects
1.	1836	Hayward	about 7.0	Ground breakage.
2.	1838	San Andreas	about 7.0	Ground breakage.
3.	1852	Big Pine	No data	Ground breakage
4.	1857	San Andreas	about 8.0	Right-lateral slip, possibly as much as 30 ft.
5.	1861	Calaveras	No data	Ground breakage.
6.	1868	San Andreas	No data	Long fissure in earth at Dos Palmas.
7.	1868	Hayward	about 7.0	Strike slip
8.	1872	Owens Valley fault zone	8.3±	Right-lateral slip, 16-20 ft., left-lateral movement may also have occurred; vertical slip, down to east, 23 ft.;
9.	1890	San Andreas	No data	Fissures in fault zone, railroad tracks moved, railroad bridge displaced.
10.	1899	San Jacinto	about 6.6	Surface evidence questionable
11.	1901	San Andreas	about 6.3	Ground breakage.
12.	1906	San Andreas	8.3	Right-lateral slip, 16 ft.
13.	1922	San Andreas	6.5	Ground breakage
14.	1934	San Andreas	6.0	Ground breakage.
15.	1934	San Jacinto fault zone in Colorado River Delta	7.1	Distinct fault trace on 1935 aerial photographs
16.	1940	Imperial	7.1	Right-lateral slip, 19 ft.
17.	1947	Manix	6.4	Left-lateral slip, 3 in.
18.	1950	Unnamed fault along west edge of Fort Sage Mountains	5.6	Vertical slip, down to west 5-8 in.
19.	1951	Superstition Hills	5.6	Right-lateral slip, slight
20.	1952	White Wolf	7.7	South-dipping re verse slip, fault left-lateral 2 ft; upthrown 2 ft.
21.	1956	San Miguel	6.8	Right-lateral slip, 3 ft.; vertical slip, down to southwest 3 ft.
22.	1966	Imperial	3.6	Right-lateral slip 1½ cm.
23.	1966	San Andreas	5.5	Right-lateral slip, several inches.
24.	1968	Coyote Creek Superstition Hills Imperial, and San Andreas	6.5	Right-lateral slip, up to 38 cm. on Coyote Creek fault; right-lateral slip, 1-2 cm. on Superstition Hills, Imperial, and San Andreas

FAULTS SHOWING CONTINUOUS OR INTERMITTENT CREEP

San Andreas fault from San Juan Bautista to Cholame
Hayward fault.
Calaveras fault zone from near Dublin to Hollister.
Imperial fault. Possible creep after 1940 Imperial Valley earthquake.
Manix fault.
Garlock fault

Drilling and fluid production will involve the same considerations during full-scale operations as during the testing and earlier production operations, including prevention of blowouts, sealing of wells, and providing for control of fluid flow from a well. Steam not containing noxious gas concentrations generally can be exhausted to the atmosphere without causing significant environmental damage if noise is kept at a moderate level. Condensing such steam could result in greater heat recovery and even augment fresh-water supplies.

Full development of a geothermal field (as with drilling, production testing, field development, and powerplant and powerline construction) could have varied impacts upon fish and wildlife. Most of the impacts would occur on, or adjacent to, the power generation plant sites and areas occupied by related facilities. There also could be impacts upon fish and wildlife from improper handling of geothermal fluids. As a geothermal field proceeds through the stages of powerplant, road, transmission line, and any byproduct facilities construction and operation, the loss of wildlife values, which began in the test drilling and production testing stages, would vary by nature of activity. The impacts of exploration, development and construction generally would tend to be of a temporary nature during the period of such activity. Impacts associated with the operational phase would continue during the life of the plant, but even here some wildlife would accept such environmental intrusion without serious consequences. Impacts could include both wildlife habitat and usage. Where existing public access would be restricted to reduce hazards to the public, or to protect plant facilities, there could be an accompanying reduction of hunting, angling, or other recreational opportunity on these lands. The importance of these losses would depend upon the amount of such use displaced and the capacity of other available habitat areas to absorb the pressures presently absorbed by the geothermal area.

Power distribution lines located in flyways or over nesting and feeding sites could cause some mortality of waterfowl, eagles, hawks, and other birds from collision and/or electrocution. The magnitude of this type of loss cannot be predicted, but would be expected to be minor.

The byproduct potential of some geothermal developments is expected to be of commercial interest. Heat may be extracted from geothermal fluids for purposes other than power generation, thereby increasing the overall thermal use efficiency and precluding the need for providing alternative sources for an equivalent energy source. It also may be feasible at some installations to extract valuable chemicals and potable water from the brines produced. Such byproducts could represent positive, beneficial environmental influences. Safeguards must be employed so that waste streams from byproduct plants do not contaminate or adversely affect the environment, for example, by contributing to air or water pollution.

Electrical-energy generation during full-scale operations may be expected to continue for many years. Initial facilities associated with both the production of electric energy and byproducts--e.g., a processing plant for extracting chemicals or minerals from geothermal fluids, and/or facilities for producing and perhaps storing fresh water--might serve as pilot

plants for making improvements and additions to the project. Likewise, operation of a plant addition might provide useful data for planning and designing the next addition. Data would be accumulated from the outset and would be available for designing environmental safeguards as well as for designing other types of improvements.

Closely allied to these environmental considerations is the need to remove and safely dispose of substances in geothermal fluids that could constitute hazards, but whose removal would not be profitable. For example, noxious constituents that may be present in the gases that remain after geothermal steam condenses. Such constituents would have to be removed and safely disposed of in waste waters being reinjected or other appropriate means. Discharge of thermal mineralized or saline fluids that could result in pollution of surface streams, lakes, and watersheds or other significant environmental damage must not be permitted.

C. MITIGATING MEASURES INCLUDED IN THE PROPOSED ACTION

Mitigation of potential environmental problems and impacts stemming from geothermal exploration and development activity can be accomplished through enforcement of applicable Federal, State, and local laws and regulations, geothermal exploration and leasing regulations, geothermal operating regulations, Geothermal Resources Operational (GRO) Orders, lease and land-use permit stipulations, and application of existing and developing and yet to be developed technologies. Although the number of geothermal installations in the world is limited, a great amount of technical and operational information has been gained from them. Certain technologies, such as drilling methods and handling of high pressure fluids, have been directly transferred with appropriate modification, from the petroleum industry to the geothermal industry. Our knowledge of environmental causes, effects, and remedial or preventive measures specifically relating to geothermal development ranges from adequate to limited. Some environmental impacts are known and can be prevented; some impacts can be anticipated and adequate environmental protection can be planned; some impacts can only be hypothesized so contingencies included under the general regulations may provide a means for corrective action in the event these impacts become reality. If unacceptable environmental factors exist which can not be corrected, development or operation would not be permitted.

Certain environmental impacts will be common to all geothermal developments while others will be unique to a single field or individual lease. All potentially known or anticipated environmental impacts which may occur from geothermal activity have been included in this statement. Unanticipated environmental impacts which become apparent as a result of the development of geothermal resources will be mitigated as indicated under Sections 270.11 and 270.12 of the operating regulations.

The environmental impacts and the mitigating measures taken to lessen or eliminate such impacts will vary depending upon the characteristics of each specific lease site and the phase of geothermal development. Unsuccessful exploration activity resulting in lease termination would result in a relatively small-scale environmental impact and prevention or mitigation of this impact could be readily accomplished. As development proceeds through the sequence of test drilling, production testing, field development, powerplant and powerline construction, and full-scale operation, the environmental impacts may become compounded and more numerous, and mitigating measures could become increasingly complex. However, proper planning, information analysis, monitoring of all operations, control measures, etc. can keep currently abreast of all activities to assure that potential problems are promptly identified and that adequate correction measures are taken.

1. General

Environmental Assessments

Section 3200.0-6 (a) of the leasing regulations provides for an initial preleasing report on resources of the proposed lease area and the potential

impact of operations on the environment. To the extent possible, such evaluations will cover all stages from resource exploration and development to full-scale operations. Appropriate Federal agencies will be asked to comment on the proposal.

Section 3200.0-6(b) of the leasing regulations provides that prior to the final selection of tracts for leasing the head of the agency charged with the administration of the surface shall evaluate fully the potential effects of the leasing program on the total environment, aquatic resources, aesthetics, recreation, and other resources in the entire area during exploration, development, and operational phases. This includes both the geothermal lease area and the construction of power generating plants and transmission facilities on lands not included in the geothermal lease. To aid in this evaluation and determination, the responsible agency may request and consider the views and recommendations of appropriate Federal agencies, hold public hearings after appropriate notice, and consult with State agencies, organizations, industries, and individuals. If, upon review of any preleasing report, it is determined that geothermal development will constitute a major Federal action significantly affecting the quality of the human environment, an environmental impact statement, as required under Section 102(2)(c) of the National Environmental Policy Act of 1969, will be prepared and issued, either as a supplement to this statement or as a separate statement. The Director, Bureau of Land Management (BLM), shall develop special leasing stipulations and conditions when necessary to protect the environment and all other resources.

Monitoring

Monitoring will be conducted for all potential impacts related to exploration, development, and production of geothermal resources. Such impacts include, but are not limited to, noise, air quality, water quality, radioactivity, erosion, fish and wildlife, seismicity, and land subsidence. Monitoring may take the form of continous recording of parameters, periodic sampling, or areal survey at intervals.

The extent and frequency of required monitoring activities will differ from place to place owing to natural variability of geology, terrain, biological factors, climate, etc. Therefore, technically appropriate measures to monitor environmental impacts will be determined on a case-by-case basis after the decision has been made to consider lease sales in a given area. In any event, it is essential that appropriate monitoring activities be instituted prior to development so that potential impacts can be subjected to an adequate before and after assessment.

Monitoring of short-term localized impacts such as noise and air quality, which are readily identified and associated with specific activity on an individual lease, will be the responsibility of the lessee, under the supervision of the U.S. Geological Survey, and will be required as a stipulation in the lease or through GRO Orders.

Monitoring of processes that cannot be readily associated with activity on an individual lease, such as changes in water quality,(including sediment yield) fish and wildlife values or processes that are of regional scope, such as land subsidence and seismicity, will be the responsibility of the Department of the Interior.

Applicability and Use of State and Local Government Environmental, Public Health and Safety and Geothermal Laws and Regulations.

To the maximum extent possible, consistent with meeting Federal responsibilities for the management and protection of public lands and their resources, appropriate consideration and utilization will be made of State and local government water quality, air quality, noise, geothermal and other laws and regulations. Section 270.41 of the regulations provides that the lessee shall comply with all Federal and State standards with respect to the control of all forms of air, land, water and noise pollution, including, but not limited to, the control of erosion and the disposal of liquid, solid and gaseous wastes. The Supervisor may, in his discretion, establish additional and more stringent standards which must be met.

Careful evaluation will be made for each geothermal project to ascertain the nature of environmental problems that may exist, the adequacy of state and local government laws and regulations, and the degree to which additional standards must be imposed to provide adequate public health and safety measures, for protection of other land and resource values, and for environmental protection. For most states, water quality regulations should cover most situations. By contrast, there may be air or noise pollution factors for which specific provisions must be developed and included in lease provisions or subsequent GRO orders. In many instances, it will not be possible to fully identify all potential environmental problems and to provide all necessary controls until the resources have been fully explored, developed, tested, their physical properties evaluated, and power generation facilities have been designed, constructed and put into operation. Accordingly, there may be a need to develop additional stipulations not included in the initial lease provisions throughout each stage of project development, including actual operations. Future changes in Federal, State and local government laws and regulations may warrant changes in environmental stipulations and controls.

In view of the growing interest in the potential for developing geothermal resources in the Western States, these states are enacting laws and regulations applicable to state and private land resource development. Table III-8 summarizes the status of such actions as of early 1973.

2. Exploration Operations

As defined in Section 3209 of the leasing regulations, exploration operations means any activity relating to the search for evidence of geothermal resources which requires physical presence upon the land and which may result in damage to public lands or resources thereon. It includes but

Table III-8. OVERVIEW OF
GEOTHERMAL LAWS AND REGULATIONS
IN THE WESTERN UNITED STATES

State	Geothermal Law	Geothermal Regulation	Geothermal Regulation State Lands	Water Well Permit Required	Drilling Fee Required	Drilling Bond Required (Thousands $)	Impact Statement to Drill Required
Alaska	No	No	Yes 1972	Yes/No	$100	Yes 15 B10	No
Arizona	Yes 1972	Yes 1972	Yes	No	$25	Yes 15 B25	No
California	Yes 1965	Pend. (1973)	Yes 1967	No	$25-1,000	Yes 15 B25	No
Colorado	No	No	No	UD	UD	UD	UD
Hawaii	No	No	No Pend.	Yes	Nom.	No	Yes
Idaho	Yes 1972	Yes (1973)	Yes 1972	Yes	$500	Yes 110 No B	No
Montana	Yes (7/73)	Yes (7/73)	Yes (7/73)	Yes	Yes $75-150	Yes 15 B10	Cond.
Nevada	No	No	No	Yes	$25+	No	No
New Mexico	Yes (6/73)	Yes (6/73)	Yes 1967	Yes	UD	UD	No
Oregon	Yes 1971	Yes 1971	Yes 1972	Yes	Yes $25	Yes 15 B25	No
Utah	Yes 1973	No	Yes	Yes	$10+	·	No
Washington	No	No	No	UD	UD	UD	No
Wyoming	Yes (5/73)	No	No	Yes	$2	No	No

( ) - Pending date   UD - Undecided

State of California
Division of Oil and Gas,
Department of Conservation,
April 1973

is not limited, to geophysical operations, drilling of shallow temperature gradient wells, construction of roads and trails, and cross country transit by vehicle over public domain. It does not include the casual use of public lands for geothermal resource exploration. It does not include core drilling for subsurface geologic information, except drilling of shallow temperature gradient wells or drilling for geothermal resources; these activities will only be authorized by the issuence of a geothermal resource lease.

Section 3209 requires that any person desiring to conduct exploration operations shall, prior to entry to entry upon the lands, file for approval with the authorized officer for the district within which the public lands are located a "Notice of Intent to Conduct Exploration Operations." No exploration operations will be conducted prior to meeting the requirements of this section. Exhibit III-A is an example of the Notice of Intent form to be used. In this manner, the authorized officer will advise those involved in exploration activities as to the general and specific terms and conditions applicable to the areas involved. The authorized officer will know who is operating in various areas, the nature of their operations, the location of such operations, and the approximate period of such operations. Appropriate surveillance then can be maintained over all exploratory operations.

In submitting the Notice of Intent, the operator will agree to conduct all exploration operations pursuant to the prescribed terms and conditions. He also will be required to file a surety bond in an amount at not less than $5000, conditioned upon the full and faithful compliance for each exploration operation. Upon completion of the exploration operation, there shall be filed a Notice of Completion of Exploration Operations. Within 90 days after the filing of such notice, the authorized officer shall notify the party who conducted the operations whether all of the terms and conditions have been complied with, or whether additional measures must be taken to rectify any damage to the land.

Under these procedures, those wishing to conduct geothermal explorations will be able to do so subject to those terms and conditions as are necessary to protect the public lands, their resources and environmental values. The authorized officer responsible for management of the public lands involved will have the opportunity to advise exploratory operators of such terms and conditions and he can monitor such activities as appropriate. Upon completion of the exploratory work, compliance will be checked and any needed corrective measures will be required.

3. <u>Leasing, Resource Development and Operations</u>

Section 3200.0-6 of the leasing regulations sets forth the following preleasing procedures;

(a) When an area is initially considered for geothermal leasing or when the need arises, the Director shall request other interested Bureaus and Federal agencies to prepare reports describing, to the extent known, resources contained within the general area and the potential effect of geothermal resources

Form 3209-1
(Sample)

EXHIBIT III-A

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Notice No.________

NOTICE OF INTENT TO CONDUCT
EXPLORATION OPERATIONS
(Geothermal Resources)

We

____________________ ____________________
(Applicant) (Address)

____________________ ____________________
(Operator) (Address)

____________________ ____________________
(Contractor(s)) (Address)

hereby apply for authorization to conduct exploration operations pursuant to the provisions of 43 CFR 3209 now or hereafter in force across and upon the following described lands (give description of lands by township; attach map or maps showing lands to be entered or affected):

The type of operations to be conducted are (give brief description):

Exploration operations will be conducted during the period from__________ to__________.
Bond attached: $______ Surface protection bond /_/; $______ Surety bond /_/; Rider to Nationwide bond /_/; Rider to Statewide bond /_/; Bond to be furnished /_/.

Upon completion of exploration operations, the undersigned agree to notify the Authorized Officer that exploration operations authorized have been completed in conformance with the general and special terms and stipulations of the notice. The undersigned agree to be bound by the terms and conditions of this notice to conduct exploration operations when approved by the Authorized Officer.

The undersigned agree that the filing of this Notice under the regulations 43 CFR Subpart 3209 does not vest or confer any preference right to a mineral lease.

The undersigned agree further that all exploration operations shall be conducted pursuant to the following terms and conditions:

1. Exploration operations shall be conducted in compliance with all Federal, State and local laws, ordinances, or regulations which are applicable to the area of operations including, but not limited to, those pertaining to fire, sanitation, conservation, water pollution, fish and game. All operations hereunder shall be conducted in a prudent manner.

2. Due care shall be exercised in protecting the described lands from damage. All necessary precautions shall be taken to avoid any damage other than normal wear and tear to improvements on the land including, but not limited to, gates, bridges, roads, culverts, cattle guards, fences, dams, dykes, vegetative cover, improvements, stock watering and other facilities.

3. All drill holes shall be capped when not in use and appropriate procedures shall be taken to protect against hazards in order to protect the lives, safety or property of other persons or of wildlife and livestock.

4. All vehicles shall be operated at a reasonable rate of speed and, in the operation of vehicles, due care shall be taken to safeguard livestock and wildlife in the vicinity of operations. Existing roads and trails shall be used wherever possible; if new roads and trails are to be constructed, the Authorized Officer must be consulted prior to construction as to location and specifications. Reclamation and/or reseeding of new roads and trails shall be made as requested by the Authorized Officer.

5. Upon expiration, conclusion, or abandonment of operations conducted pursuant to this notice all equipment shall be removed from the land, and the land shall be restored as nearly as practicable to its original condition by such measures as the Authorized Officer may specify. All geophysical holes shall be safely plugged. The Authorized Officer shall be furnished a "Notice of Completion of Exploration Operations" (Form 3209-2) immediately upon cessation of all such operations and shall be further informed of the completion of reclamation work as soon as possible.

6. Location and depth of water sands encountered shall be disclosed to the Authorized Officer.

7. Operator shall contact the Authorized Officer prior to actual entry upon the land in order to be apprised of practices which shall be followed or avoided in the conduct of exploration operations pursuant to the terms of this Notice and applicable regulations.

8. Due care shall be exercised to avoid scarring or removal of ground vegetative cover.

9. All operations shall be conducted in such a manner to avoid: (a) blockage of any drainage systems; (b) changing the character, or causing the pollution or siltation of rivers, streams, lakes, ponds, waterholes, seeps and marshes; and (c) damaging fish and wildlife resources or habitat. Cuts or fills causing any of the above-mentioned problems will be repaired immediately in accordance with specifications of the Authorized Officer.

10. Vegetation shall not be disturbed within 300 feet of waters designated by the Authorized Officer, except at approved stream crossings.

11. Surface damage which induces soil movement and/or water pollution shall be subject to corrective action as required by the Authorized Officer.

12. Trails and campsites shall be kept clean. All garbage and foreign debris shall be eliminated as required by the Authorized Officer.

13. Operator shall protect all survey monuments, witness corners, reference monuments, and bearing trees against destruction, obliteration, or damage. He shall, at his expense reestablish damaged, destroyed or obliterated monuments and corners, using a licensed surveyor, in accordance with Federal survey procedures. A record of the reestablishment shall be submitted to the Authorized Officer.

14. Operator shall make every reasonable effort to prevent, control, or suppress any fires started by the operator and to report as soon as possible to the Authorized Officer location and size of fires and assistance needed to suppress such fires. Operator shall inform the Authorized Officer as soon as possible of all fires, regardless of location, noted or suppressed by independent action.

15. No work shall be done within one-quarter mile of a developed recreation site without specific written authority from the Authorized Officer. Any travel within one-quarter mile of a recreation site shall be over existing roads or trails.

16. Use of explosives within one-fourth mile of fishery waters is prohibited unless approved, in writing, by the Authorized Officer.

17. If operations conducted under the provisions of this Notice causes any damage to the surface of the national resource lands, such as, but not limited to, soil erosion, pollution of water, injury or destruction of livestock or wildlife, or littering, operator shall within 48 hours file with the Authorized Officer a map showing exact location of such damage and a written report containing operator's plans for correcting or minimizing damage, if possible.

18. Failure to comply with any of these terms and conditions shall result in immediate shutdown of field operations until deficiency is corrected. Failure to correct deficiency within the time period allowed by the Authorized Officer shall result in forfeiture of bond.

19. The Bureau of Land Management reserves the right to impose a closure of any area to operators in periods when fire danger or other dangers to natural resources are severe.

20. Contractor shall be liable for assuring compliance with all terms and conditions of this Notice and all actions of his designated operator, agents and employees.

21. Special Stipulations:

Signature of Applicant (Date)	Signature of Operator (Date)

Agreement: We hereby agree to the special stipulations added and made a part of this Notice to conduct exploration operations.

Signature of Holder of Notice (Date)	Signature of Operator (Date)

Approved: I hereby approve this Notice to Conduct Exploration Operations.

Signature of Authorized Officer (Date)

Title

Form 3209-2
(Sample)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

NOTICE OF COMPLETION OF GEOTHERMAL RESOURCES
EXPLORATION OPERATIONS

Name	Address

Pursuant to the Notice ____________ (Notice Number) heretofore filed to conduct geothermal resource exploration operations, this is to advise that such operations were completed ____________ (Date), on the lands described in the previousNotice.

____
(Operator's Signature)

____
(Address)

____
(Date)

Instructions: Operator prepares, in duplicate, upon completion of exploratory work. Send original to case file and retain carbon.

operations upon the resources of the area and its total environment.

(b) Prior to the final selection of tracts for leasing, the Director, or the head of the agency charged with the administration of the surface, when requested by the Director, shall evaluate fully the potential effect of the leasing program on the total environment, fish and other aquatic resources, wildlife habitat and populations, aesthetics, recreation, and other resources in the entire area during exploratory, developmental, and operational phases. This evaluation will consider the potential impact of the possible development and utilization of the geothermal resources including the construction of power generating plants and transmission facilities on lands which may or may not be included in a geothermal lease. To aid him in his evaluation and selection of tracts, the Director may request and consider the views and recommendations of appropriate Federal agencies, may hold public hearings after appropriate notice, and may consult with State agencies, organizations, industries, and individuals, and shall consider all other potential uses of the land and its natural resources.

If the Director determines that the issuance of leases in an area would be a major Federal action significantly affecting the quality of the human environment, he shall issue no leases in that area until an environmental im-impact statement under section 102(2)(C) of the National Environmental Policy Act of 1969 (42 U.S.C. 4332(2)(C)) has been issued.

The Director shall develop special terms and conditions to be included in leases when they are needed to protect the environment, to permit use of the land for other purposes, and to protect other natural resources. If tracts are offered for competitive leasing, any terms and conditions to be included in leases for such tracts shall be published in the place announcing the availability of the land for leasing.

The procedures are designed to assure that adequate environmental evaluations are made prior to all proposed leasing actions and that all leases contain whatever special terms and conditions needed to protect the environment, to permit use of the land for other purposes, and to protect other natural resources. This, in turn, provides the framework within which all exploration, resource development, construction and operations as provided for within each lease shall be conducted and controlled.

Specific Enforcement Provisions

As appropriate, specific environmental protection provisions are included throughout the regulations. However, in view of the wide variation of

physical factors that exist among individual sites; the related Federal, State or local government environmental laws, regulations and policies; the need for additional resource and environmental information on a site-sensitive and subregional basis; potential changes in exploration, development and use technologies; etc., the regulations generally can provide only broad guidelines which must be properly interpreted, translated, and incorporated into each lease or permit based upon its particular social, economic, land use, natural resource, environmental, and other significant considerations

Section 270.11 of the operating regulations provides authority to the Supervisor to issue detailed written GRO Orders to implement the geothermal regulations. Such orders will apply to operations in a given area or region. Orders so issued will form a part of the operating regulations for the applicable area and will be enforced in the same manner as the regulations. The Supervisor also may prescribe or approve variances from GRO Orders (Section 270.48) when necessary for proper control of a well, conservation of natural resources, protection of human health and safety, property, or the environment.

The basic requirement that lessees (including operators) take all reasonable precautions to prevent all types of adverse environmental effects is given in Section 270.30. The obligations and duties of lessees as related to specific impacts are set forth in Section 270.40, Well control; Section 270.41, Pollution; Section 270.42, Noise abatement; Section 270.43, Land subsidence and seismic activity; Section 270.44, Pits or sumps; Section 270.45, Well abandonment; Section 270.46, Accidents; and Section 270.47, Workmanlike operations.

Blowouts or uncontrolled releases of steam or hot water are a major concern throughout geothermal operations. The worldwide experience in the past few decades with mishaps of this type are reviewed under Test Drilling in Chapter III of this statement. Section 270.40 requires the lessee or operator to take precautions to keep all wells under control at all times, to utilize trained and competent personnel, to properly maintain equipment and materials, and to use safe operating practices. Although blowouts result from a broad range of causes reflecting the great geologic diversity of the geothermal fields, blowouts can be avoided or brought under control by use of appropriate techniques (English, 1964; Bolton, 1964; Cigni, et al., 1972). Section 270.40 outlines the technical considerations essential for effective preventive and correctional well control procedures. The selection of the types and weights of drilling fluids and provisions for controlling fluid temperatures, blowout preventers, and other surface control equipment and materials, casing and cementing programs, etc., to be used shall be based on sound engineering principles and shall take into account apparent geothermal gradients, depths and pressures of the various formations to be penetrated, and other pertinent geologic and engineering data relating to the area. Since the establishment of State regulatory controls governing the drilling of geothermal wells on private lands there have been no well blowouts due to improper drilling techniques.

Specific requirements related to accident prevention may be included as lease stipulations or by GRO Orders. Section 270.46 requires that all accidents on leased land be reported to the Supervisor within 24 hours and that full reports be submitted within 15 days. This provision would include accidents involving blowouts. Accidental uncontrolled release of geothermal fluids at abandoned wells are preventable by the provisions of Section 270.45, which requires approval of plugging procedure by the Supervisor.

Both the leasing and operating regulations provide penalties for failure to comply with appropriate leasing and operating regulations, including failure to provide environmental protection. Section 3244.3 of the leasing regulations provides for termination of the lease after due notice for any violation of the leasing regulations or lease terms. Section 3206 requires separate bonds to insure compliance with the terms of the lease and to insure protection of surface rights. Liability under any bond will not be terminated until all lease terms and conditions have been fulfilled.

Section 270.12 of the operating regulations provides, among other things, that the authorized field officials of the Department shall inspect and supervise geothermal operations in order to implement the regulations to prevent damage to natural resources, prevent degradation of water quality, protect other environmental qualities, and prevent injury to life and property. This includes inspection and supervision of operations to determine whether such activity would cause subsidence of the land surface and, if so, whether the potential subsidence would be unacceptable in the circumstances. This section also provides that the authorized field official shall issue orders as necessary to accomplish these purposes.

Section 270.80 provides that whenever a lessee fails to comply with the provisions of the regulations or lease terms, the Supervisor may suspend all of the lessee's operations under his jurisdiction and shall give the lessee notice to remedy the faults or violations. Failure to perform or commence the required remedial action will result in the suspension of operations and may result in cancellation of the lease.

Appeals by the lessee on violations may be made to higher authorities (Section 270.90). Compliance with any order issued to remedy a violation shall not be suspended by reason of such appeal except as authorized by the Director of the Geological Survey or the Secretary, conditioned upon the posting and acceptance of a bond or a determination that reinstatement will not be detrimental to the lessor.

a. Land Resources

The Geothermal Steam Act of 1970 excludes certain public, acquired, and Indian lands from the geothermal leasing program to protect their special land use values or the unique characteristics of these lands. These include: lands administered by the National Park Service; lands within national recreation areas; lands used for fish hatcheries; wildlife refuges, wildlife or

game range lands, wildlife management areas, waterfowl production areas, or lands reserved to protect and conserve species threatened with extinction; and Indian lands. These excepted lands are also described under Section 3201.1-6 of the leasing regulations. In addition, lands administered by the Department of Agriculture, such as national forest and wilderness lands, and lands withdrawn under the Federal Power Act (16 U.S.C. 818) may be leased for geothermal development only with the consent and under the conditions prescribed by the agency heads administering these lands. Geothermal resources on lands withdrawn or acquired in aid of functions of the Department of the Interior may be leased only if it has been determined that such leasing will not be contrary to the purpose for which the land was withdrawn.

In addition to restricting certain areas from geothermal leasing, Section 3200.0-6(b) of the leasing regulations requires that developments on adjacent lands, both public and private, must be evaluated prior to geothermal leasing, to consider the impact of geothermal development on surrounding land uses. Incompatibility of land use can eliminate certain areas from prospective geothermal leasing. Geothermal activities on leased lands must be conducted in such a manner as to prevent unreasonable interference with multiple use of lands (Sections 270.11 and 270.15 (f)) of the operating regulations).

Land use in the vicinity of geothermal developments will be changed by the construction of roads, wells, pipelines, powerlines, powerplants, and by-product facilities associated with industrial development. Land used for agriculture, forestry, grazing, fish and wildlife habitat, recreation, and water supply will be disturbed in varying degrees. Mitigating measures to control, reduce, or overcome adverse impacts on land resources from geothermal developments include actions such as land-use planning, environmental evaluations and monitoring, sound engineering and construction processes, land reclamation, maintenance of neat and orderly operations, provision for public access, subsidence prevention, etc.

Comprehensive planning, beginning with the earliest stages of a geothermal leasing program and continuing through full-scale operations, can contribute greatly to harmonious layout and design, appropriate utilization of land surface, minimum heat loss, environmental protection, and general efficiency. If there is authorized existing use of the land surface for nongeothermal purposes, geothermal development would not be allowed to unreasonably interfere with the continued utilization of the surface for such purposes (Section 3200.0-8 of the leasing regulations).

Although geothermal development may have a negative impact on certain land uses, it may have a positive value in providing greater public access to remote or isolated areas. Creation of new access routes or improvement of existing access roads can open new areas to multiple-use development. Such routes also can serve as fire breaks or provide access for fire protection in areas subject to grass, brush or forest fires.

Geothermal developers on Federal lands are required to take aesthetics into account during planning, design and construction of facilities (Section 3204.1 (f)). Leases will include provisions that, to the extent practicable, structures, including power-transmission facilities and enclosures for generating plants, be designed to meet existing local or other applicable architectural standards. The facilities should be designed to blend harmoniously with the surrounding environment and to have a reasonably artistic and pleasant appearance in accordance with Environmental Criteria for Electrical Transmission Systems (1970).

Each operator is required to maintain the lease lands in a safe and workmanlike manner at all times and to remove or store all supplies and scrap in an orderly fashion (Section 270.47).

Geothermal developments on lands known or suspected to contain archeological, paleontological, or historical sites must be conducted to protect or preserve these sites in accordance with Section 3204.1(h) of the leasing regulations, specific lease stipulations, and with the regulations set forth in 43 CFR, Part 3 requires that historical sites be preserved in place whenever possible; requires that proper officials be notified of the discovery of new sites; provides for arrest for unauthorized removal or destruction of artifacts or structures; and for confiscation of any articles removed from the site.

Section 3204.1(b) of the leasing regulations provides for free and unrestricted public access to geothermal lease lands. Restrictions on access, where necessary to protect public health and safety or where access would unduly interfere with geothermal operations, are not allowed without prior approval. Warnings, fencing, flag men, barricades, and other safety measures must be provided by the lessee to protect the public, wildlife, and livestock from hazardous geothermal-related activities.

Lands will be disturbed as a result of geothermal leasing and development activity. Numerous provisions for the restoration of land surfaces upon abandonment or completion of geothermal activities are included in the leasing and operating regulations. Section 3204.1(i) requires restoration of all disturbed lands in a manner approved by the Supervisor. Section 3209.3 requires, upon completion of exploratory operations, that the District Manager will notify the lessee whether any additional measures must be taken to rectify any damage to the land. Section 3244.1(2)(a) requires that upon relinquishment of a lease, a statement be submitted as to whether the relinquished land had been disturbed and, if so, whether it was restored as prescribed by the terms of the lease. Appropriate compliance inspections will be made.

Section 270.41 of the operating regulations requires that the lessee shall comply with all Federal and State standards with respect to the control of all forms of air, land, water, and noise pollution, including, but not limited to, the control of erosion and the disposal of liquid, solid, and gaseous wastes. The Supervisor may, in his discretion, establish additional and more stringent standards. Section 270.44 requires that when

no longer needed, pits and sumps will be filled and covered and the premises restored to a near-natural state as prescribed by the Supervisor. Section 270.45 requires that the premises at the well site shall be restored as near as reasonably possible to its original condition immediately after plugging operations are completed on any well, except as authorized by the Supervisor. Section 270.46 requires notification of the Supervisor on all acidents on the lease and reports on same.

Proper reclamation and revegetation of lands, during geothermal development and at completion of geothermal activities, can reduce the size of, or restore, denuded areas which will result in decreased dust generation and soil erosion. Revegetation practices and chemical stabilization techniques have been developed for various soil types and climatic and topographic conditions. Many of these techniques, developed for use by highway departments, mining companies, park and recreational groups, landscape architects, and Federal, State and local governmental agencies can be directly applied to reclamation of geothermal lease lands. Specific revegetation methods will be specified by GRO Order or lease stipulation.

Section 3204.1(d) of the leasing operations additionally requires the lessee to remove or dispose of all waste, including but not limited to, human waste, trash, garbage, refuse, petroleum products, and extraction and processing waste generated in connection with the operation, in a manner acceptable to the Supervisor.

GRO Orders or lease stipulations will be issued as appropriate to require specific land reclamation activities which are not mentioned in the leasing and operating regulations. In addition to restoring disturbed lands, the lessee is required to provide erosion controls to prevent degradation of the land, disturbance of vegetation, and stream damage (Section 3204.1 (c)(4) and Section 270.41).

Subsidence of the ground surface over and around a geothermal reservoir may result from the withdrawal of geothermal fluids. The lessee is required by Section 3204.1(e) of the leasing regulations to take precautions necessary to minimize subsidence, including the maintenance of subsidence monitoring equipment where stipulated. Subsidence may be controlled through the use of reinjection wells to return fluids to the reservoir formation or to formations with direct hydrologic communication with the reservoir formation.

Some degree of subsidence may be tolerable at certain geothermal lease areas while at other locations, such as agricultural areas in the Imperial Valley, even slight amounts of subsidence could affect irrigation systems or other land uses. The quantity of fluid reinjected to stabilize an area like Imperial Valley may have to equal or exceed the quantity of fluid withdrawn. In noncritical areas, the reinjection of waste geothermal fluids may be sufficient to prevent undue subsidence of the surface.

Certain geothermal areas may presently be subsiding from natural causes unrelated to geothermal fluid production. Monitoring of the land surface

prior to commencement of geothermal exploration activity can aid in determining the general stability of the lease lands. Level networks established by the State of California and the National Geodetic Survey (NGS) in the Imperial Valley prior to geothermal production activity will provide a frame of reference for monitoring of subsidence. Leveling for a similar network for The Geysers area is programmed by NGS for 1973. Detection of subsidence attributable to geothermal production activity may indicate that sufficient quantities of fluid are not being reinjected. Increasing the reinjection rate may stabilize the area against further subsidence but probably will not result in raising of the land surface to its original elevation.

GRO Orders and lease stipulations will, as appropriate, be attached to the lease provisions to insure that necessary subsidence prevention measures are practiced by the lessee. In areas where subsidence cannot be tolerated, geothermal leasing may not be environmentally feasible.

The fact that geothermal areas occur in close association with earthquake zones must be considered fully in the lay out of the facilities and design of structures, particularly those handling superheated steam or hot water. The construction of separators, pipelines, transformer stations, and other mechanical and electrical equipment, as well as buildings, must be in accordance with current earthquake engineering practices. Although it is not possible, at present, to either predict when an earthquake may occur or to prevent earthquakes, the evaluation of the historical record and potential natural seismicity provides a basis for rational seismic design.

Careful records are to be maintained on production and reinjection rates and pressures of geothermal fluids. Provisions for monitoring seismicity of the field before and during production may be stipulated as set forth in Section 3204.1(e) of the leasing regulations. If monitoring indicates a significant increase in seismicity, particularly in intensity of motion, remedial steps as required by the lease or deemed necessary by the Supervisor will be initiated (Section 270.43). These remedial steps include limiting the rate of withdrawal or reinjection in the area of increased seismicity.

b. Air Resources

General provisions for prevention of air pollution and related employee health and safety are included in the proposed leasing regulations, Sections 3204.1(c)(3), 3204.1(c)(5), and 3210.2-1, and in the proposed operating regulations, Sections 270.30, 270.40, 270.41, and 270.46. In addition, the various Federal and State regulations dealing with air quality are applicable; lease stipulations or GRO Orders may be issued (Section 270.11); and technologic means may allow mitigation of air pollution and related health and safety hazards.

Air Quality

Dust generated by movement of vehicles and airborne dust resulting from earthmoving and construction activity contributes particulate matter to the atmosphere. National and State primary and Secondary ambient air quality standards for total particulates and certain gases in the atmosphere are shown in Tables III-9 and III-10. Methods are available to treat roads and construction sites to minimize dust generation. Watering of roadways and excavations holds down dust and is a method frequently used on temporary roads during periods of heavy traffic. Oiling or chemical treatment of roads is more effective in reducing dust but is more expensive than watering and is generally restricted to use on more permanent roads. Paving of roads with asphalt or concrete provides a long-term solution to vehicle-generated dust but, due to cost, is generally used only for permanent roads. Paving can be expected only if powerplants are constructed in a geothermal field. GRO Orders to control the generation of dust can be issued by the Supervisor under Section 270.41 of the operating regulations.

Vehicle and power source emissions contribute to total air-quality degradation to which State and National primary and secondary ambient air quality standards apply. Pollution from motor vehicle engines and internal combustion power sources is in part regulated by 40 CFR 85, Control of Pollution From Motor Vehicles and New Motor Vehicle Engines. These regulations apply to new vehicles but are not applicable after the vehicle or engine passes to the user. Modifications or lack of maintenance on engines can decrease the effectiveness of pollution-control devices. In California, the State Motor Vehicle Pollution Control Standards, which currently are more strict than the Federal standards, are applicable. GRO Orders can be issued to reduce emmissions from vehicles and internal-combustion power sources.

Release of gases and vapors associated with geothermal steam to the atmosphere must be in accord with National and State primary and secondary ambient air quality standards, safety and health standards, lease stipulations and any GRO Orders. The National Primary and Secondary Ambient Air Quality Standards, 40 CFR 50, as established, deal with only one gas, carbon monoxide, associated with geothermal fluids. (Table III-9). Discharge of carbon monoxide from geothermal sources must meet this standard.

State ambient air quality standards for those western states with potential for geothermal development are summarized in Table III-10. For the most part, these State standards apply only to carbon monoxide and particulate matter. Some states have, however, established standards for dust and hydrogen sulfide. Geothermal developments must conform to the applicable State ambient air quality standards. In addition to the ambient standards, any geothermal development which takes place within certain designated State air basins must meet any additional standards for that basin. Many such standards are being formulated at the present time.

Table III-9. National primary and secondary ambient air quality standards for carbon monoxide and particulates

Carbon Monoxide	
Primary	10 milligrams per cubic meter (9 ppm)
	Maximum 8-hour concentration not to be exceeded more than once per year
Secondary	40 milligrams per cubic meter (35 ppm)
	Maximum 1-hour concentration not to be exceeded more than once per year
Particulate Matter	
Primary	75 micrograms per cubic meter (annual geometric mean)
	260 micrograms per cubic meter
	Maximum 24-hour concentration not to be exceeded more than once per year
Secondary	60 micrograms per cubic meter (annual geometric mean)
	150 micrograms per cubic meter
	Maximum 24-hour concentration not to be exceeded more than once per year

Table III-10

State ambient air quality standards for States with geothermal potential

State	Particulates	Carbon monoxide	Dust	H_2S
Alaska	60 micrograms/M^3 annual geometric mean 150 micrograms/M^3 24-hour maximum not to be exceeded more than once per year	10 milligrams/M^3 8-hour maximum not to be exceeded more than once per year 40 milligrams/M^3 1-hour maximum not to be exceeded more than once per year		
Arizona	70 micrograms/M^3 annual geometric mean 100 micrograms/M^3 24-hour maximum	7,000 micrograms/M^3 (8 ppm) 8-hour maximum 38,000 micrograms/M^3 (43.5 ppm) 90-minute maximum 6,000 micrograms/M^3 (6.9 ppm) Maximum 7-day average		
California	60 micrograms/M^3 annual geometric mean 100 micrograms/M^3 24-hour maximum	20 ppm 8-hour maximum		0.03 ppm 1-hour average

Table III-10

State ambient air quality standards for States with geothermal potential (continued)

State	Particulates	Carbon monoxide	Dust	H_2S
Coloradc	45 micrograms/M^3 annual arithmetic mean of all 24-hour concentrations 150 micrograms/M^3 24-hour maximum not to be exceeded more than once in a 12-month period	"Not to exceed National* Standards"		
Hawaii	100 micrograms/M^3 average value during any 24-hour period 55 micrograms/M^3 annual arithmetic mean value during any 12-month period	10 milligrams/M^3 average value during any 1-hour period 5 milligrams/M^3 average value during any 8-hour period		
Idaho	Primary 75 micrograms/M^3 annual geometric mean 260 micrograms/M^3 maximum 24-hour concentration not to be exceeded more than once per year	10 milligrams/M^3 (9 ppm) maximum 8-hour concentration not to be exceeded more than once per year	0.8 milligrams per square centimeter per month not to be exceeded more than 25% of the time	

Table III-10 (cont)

State ambient air quality standards for States with geothermal potential (continued)

State	Particulates	Carbon monoxide	Dust	H_2S
Idaho	Secondary			
	60 micrograms/M^3 annual geometric mean	40 milligrams/M^3 (35 ppm) maximum 1-hour concentration not to be exceeded more than once per year		
	150 micrograms/M^3 maximum 24-hour concentration not to be exceeded more than once per year			
Montana	75 micrograms/M^3 annual geometric mean	"Not to exceed National* Standards"	15 tons per square mile per month, 3-month average in residential areas	0.03 ppm 1/2-hour average not to be exceeded more than twice in any 5 consecutive days
	200 micrograms/M^3 not to be exceeded more than 1% of days a year		30 tons per square mile per month, 3-month average in heavy industrial areas	0.05 ppm 1/2-hour average not to be exceeded over twice a year
New Mexico	150 micrograms/M^3 24-hour average	8.7 ppm 8-hour average		
	110 micrograms/M^3 7-day average	13.1 ppm 1-hour average		
	90 micrograms/M^3 30-day average			
	60 micrograms/M^3 annual geometric mean			

Table III-10 (cont)

State ambient air quality standards for States with geothermal potential (continued)

State	Particulates	Carbon monoxide	Dust	H_2S
New Mexico (continued)	Asbestos presenting particulate maximum concentration 0.01 micrograms/M^3 based on a 30-day average			
Nevada	60 micrograms/M^3 annual geometric mean	10,000 micrograms/M^3 (9.0 ppm) maximum 8-hour concentration		
	150 micrograms/M^3 maximum 24-hour concentration	40,000 micrograms/M^3 (35.0 ppm) 1-hour concentration		
Oregon	60 micrograms/M^3 annual geometric mean	10 milligrams/M^3 (8.7 ppm) maximum 8-hour average not to be exceeded more than once per year	10 grams/square meter per month in industrial area	
	100 micrograms/M^3 24-hour concentration for more than 15% of the samples collected in any calendar month		5.0 grams per square meter per month in an industrial area if visual observations show a presence of wood waste or soot and the volatile fraction of the sample exceeds 70%	

Table III-10 (cont)

State ambient air quality standards for States with geothermal potential (continued)

State	Particulates	Carbon monoxide	Dust	H_2S
Oregon (continued)	150 micrograms/M^3 24-hour concentration not to be exceeded more than once per year	40 milligrams/M^3 (35 ppm) maximum 1-hour average not to be exceeded more than once per year	5.0 grams per square meter per month in residential and commercial areas 3.5 grams per square meter per month in residential and commercial areas if visual observations show presence of wood waste or soot and the volatile fraction of the sample exceeds 70%.	
Utah	90 micrograms/M^3 annual geometric mean not more than 1% of the samples collected between April 1 and October 31; not more than 5% of the samples collected between November 1 and March 31 shall exceed a concentration of 200 micrograms/M^3	9 ppm maximum 8-hour concentration not to be exceeded more than once per year 35 ppm maximum 1-hour concentration not to be exceeded more than once per year		

Table III-10 (cont)

State ambient air quality standards for States with geothermal potential (continued)

State	Particulates	Carbon monoxide	Dust	H_2S
Washington	60 micrograms/M^3 annual geometric mean 150 micrograms/M^3 maximum 24-hour concentration not to be exceeded more than once per year	10 milligrams/M^3 (9 ppm) 8-hour average concentration not to be exceeded more than once per year 40 milligrams/M^3 (35 ppm) 1-hour average concentration not be exceeded more than once per year	10 grams per square meter per month in industrial areas 5 grams per square meter per month in an industrial area if visual observations show a presence of wood waste or soot and the volatile fraction of the sample exceeds 70% 5 grams per square meter per month in residential or commercial areas 3.5 grams per square meter per month in residential or commercial areas if visual observations show a presence of wood waste or soot and the volatile fraction of the sample exceeds 70%	
Wyoming	60 micrograms/M^3 annual geometric mean 150 micrograms/M^3 maximum 24-hour concentration not to be exceeded more than once per year	10 milligrams/M^3 (9 ppm) maximum 8-hour concentration not to be exceeded more than once per year 40 milligrams/M^3 (35 ppm) maximum 1-hour concentration not to be exceeded more than once per year	5 grams per square meter per month for any 30-day period in residential areas. Includes 1.7 grams per square meter background. 10 grams per square meter for any 30-day period in industrial areas. Includes 1.7 grams per square meter background.	70 micrograms/M^3 1/2-hour average not to be exceeded more than two times per year 40 micrograms/M^3 1/2-hour average not to be exceeded more than two times in any 5 consecutive days

Standards for air contaminants established pursuant to the Occupational Safety and Health Act of 1970 (PL 91-596) for these gases and vapors associated with geothermal fluids are as follows:*

Subpart G - Occupational Health and Environmental Control 1910.93

Air contaminants (gases, vapors, fumes, dust, and mists)

(a) Exposures by inhalation, ingestion, skin absorption, or contact to any material or substance (1) at a concentration above these specified in the "Threshold Limit Values of Airborne Contaminants for 1970" of the American Conference of Governmental Industrial Hygienists, listed in Table G-1, except for the American National Standards listed in Table G-2 of this section and except values of mineral dusts listed in Table G-3*of this section, and (2) concentrations above these specified in Tables G-1, G-2, and G-3*of this section, shall be avoided, or protective equipment shall be provided and used.

(b) To achieve compliance with paragraph (a) of this section, feasible administrative or engineering controls must first be determined and implemented in all cases. In cases where protective equipment, or protective equipment in addition to other measures, is used as the method of protecting the employee, such protection must be approved for each specific application by a competent industrial hygienist or other technically qualified source.

Table G-1

Substance	p.p.m[a]	mg/M^3[b]
Ammonia	50	35
Carbon dioxide	5,000	9,000
Carbon monoxide	50	55

a. Parts of vapor or gas per million parts of contaminated air by volume at 25°C. and 760 mm Hg pressure.
b. Approximate milligrams of particulate per cubic meter of air.

Table G-2

Substance	Acceptable ceiling concentration
Hydrogen sulfide (37.2 - 1966)	20 p.p.m.
Mercury (37.8 - 1971)	1 mg / 10 m^3

Federal Register, Saturday, May 29, 1971, Washington, D.C., Volume 36, Number 105, Occupational Safety and Health Administration pp. 10465-10714

* Table G-3 not directly applicable so not quoted here.

The venting of steam to the atmosphere can create an adverse environmental impact if the steam contains significant amounts of noxious gases. Venting of noncondensible gases to the atmosphere in many instances would require sufficient removal or dilution of the gases to meet ambient air quality standards particularly where the point source may be in excess of the standards. It is likely that many natural geothermal phenomena in these areas are contributing quantities of H_2S and other gases to the atmosphere which may be in excess of National or State standards. Monitoring of air quality, both before and after geothermal development, is necessary to properly fix the sources of air pollution and to determine control actions to be required. Under provision of Section 270.41 of the operating regulations, the Supervisor may establish more stringent air quality standards for a geothermal lease through the issuance of GRO orders.

Although removal of noxious gases is chemically possible using various new techniques, the economic justification of such systems remains to be established. There are good indications that systems can be developed which will remove noxious gases and vapors from geothermal steam at the power plants. Although no such system has yet been installed at any geothermal power plant, research is being conducted to evaluate a variety of removal systems which are being used by other industries, particularly the petroleum refining industry. The Pacific Gas and Electric Company's research relative to its Geysers installations has achieved abatement of 70 percent of cooling tower H_2S emissions. Over 90 percent abatement was achieved over short time periods.

Analysis will be required to determine the presence and quantity of mercury vapor which may be present in geothermal fluids or gasses. Although there are no National or State air quality standards for mercury, there are occupational safety and health standards which are applicable to the discharge of mercury. Research is required to establish National or State primary and secondary emission standards for this element. Each geothermal project will have to be individually evaluated to ascertain if mercury is a potential problem as a basis for establishing related stipulations and control measures.

Maximum permissible concentration of radionuclides in air for occupational exposures as established by the Atomic Energy Commission (10 CFR 150.20) for those radionuclides which may be associated with geothermal resources are:

Radionuclide	Organ of Reference	Maximum Permissible Mc/cc * 40-hour week	Exposures Mc/cc * 168-hour week
Ru 220	Lung	3×10^{-7}	1×10^{-7}
Ru 222	Lung	3×10^{-8}	1×10^{-8}
Ra 223	Total Body	3×10^{-9}	1×10^{-9}
Ra 224	Total Body	8×10^{-9}	3×10^{-9}
Ra 226	Total Body	5×10^{-11}	2×10^{-11}
Ra 228	Total Body	9×10^{-11}	3×10^{-11}

* Microcuries per cc.

Occupational exposures to radioactive substances can be readily determined through the use of personal film exposure badges worn by employees. If radioactive elements are detected in the steam in sufficient quantities in excess of background levels, film badges will be required. The influence on air quality due to release of radon gas also must be determined as air quality standards do not exist for such material. Extraction of radioactive substances from geothermal steam is not now possible. If these concentrations should be sufficiently large to pose an unacceptable health or safety hazard, operations would have to be terminated.

Concentration of airborne asbestos fibers in working areas during fabrication and installation of asbestos insulation must conform to the standards established in 40 CFR 61, subpart B, "The National Emissions Standards for Asbestos." Protective devices for workers may be required or different forms of insulation such as fiberglas may be substituted for asbestos if asbestos fibers cause a health hazard. GRO Orders may be issued by the Supervisor under Section 270.41 of the operating regulations requiring more stringent standards for asbestos emissions.

Disposal and/or burning of trash and wastes on Federal lands is regulated under provisions of 40 CFR 176, "Prevention, Control, and Abatement of Air Pollution From Federal Government Activities; Performance Standards and Techniques of Measurement." As the geothermal leasing program and subsequent operations constitute a government activity on Federal land, the provisions of this regulation apply to the lessee. In addition, the Supervisor may issue GRO Orders under Section 270.12 setting more stringent standards or prohibiting burning or disposal of trash. Under Section 270.47, "The lessee shall remove from the property or store, in an orderly manner, all scrap or other materials not in use." Thus, under provisions of both the leasing and operating regulations the lessee may be required, both during and upon termination of the lease, to remove waste materials from the property.

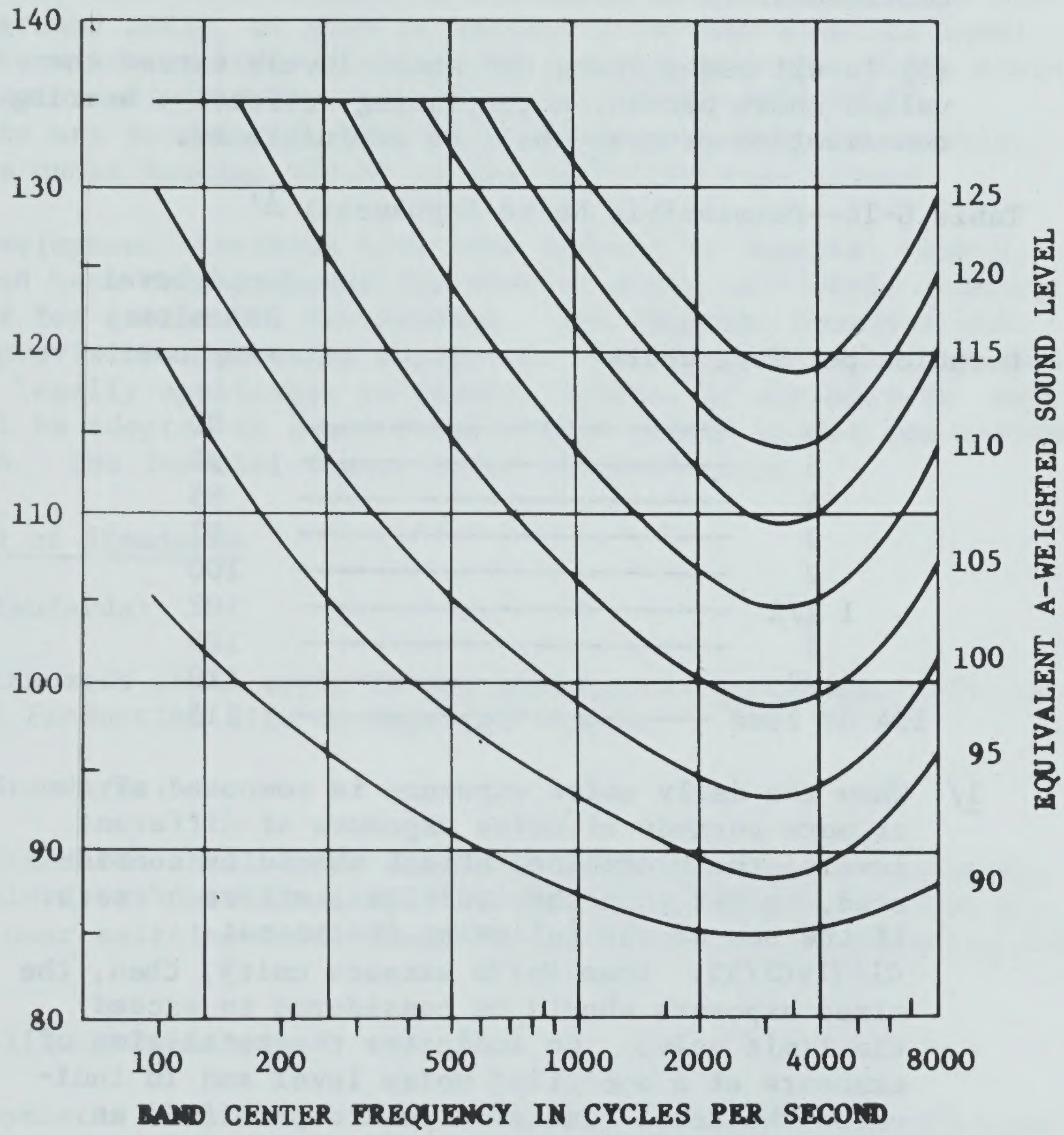
Although the potential for accidental fires exists, safeguards will be required to minimize this potential. Instructions and notices to field personnel regarding fire prevention methods, installation of spark arrestors on engines, development of contingency plans for rapid extinguishment of accidental fires, and strategic location of firefighting equipment are examples of action to be used in preventing or controlling accidental fires.

Noise

Noise due to steam ejection or expansion, drilling operations, construction activity, and other related geothermal activities may pose serious health and environmental hazards. Federal occupational noise exposure levels which apply to geothermal activity have been established pursuant to Sections 6(a) and 8(g) of PL 91-596, "The Occupational Safety and Health Act of 1970," and appear as regulations in 29 CFR 1910 as follows:

1910.95 Occupational noise exposure

(a) Protection against the effects of noise exposure shall be provided when the sound levels exceed those shown in Table B-16 when measured on the A scale of a standard sound level meter at slow response. When noise levels are determined by octave band analysis, the equivalent A-weighted sound level may be determined as follows:



Equivalent sound level contours. Octave band sound pressure levels may be converted to the equivalent A-weighted sound level by plotting them on this graph and noting the A-weighted sound level corresponding to the point of highest penetration into the sound level, which may differ from the actual A-weighted sound level of the noise, is used to determine exposure limits from Table G-16.

(b) (1) When employees are subjected to sound exceeding those listed in Table G-16, feasible administrative or engineering controls shall be utilized. If such controls fail to reduce sound levels within the levels of Table G-16, personal protective equipment shall be provided and used to reduce sound levels within the levels of the table.

(2) If the variations in noise level involve maxima at intervals of 1 second or less, it is to be considered continuous.

(3) In all cases where the sound levels exceed the values shown herein, a continuing, effective hearing conservation program shall be administered.

Table G-16--Permissible Noise Exposures: 1/

Duration per day, hours	Sound level dBA slow response
8	90
6	92
4	95
3	97
2	100
1 1/2	102
1	105
1/2	110
1/4 or less	115

1/ When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions: $C1/T1+C2/T2$. When Cn/Tn exceeds unity, then, the mixed exposure should be considered to exceed the limit value. Cn indicates the total time of exposure at a specified noise level and Tn indicates the total time of exposure permitted at that level.

Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.

In addition to the Federal standards, many states have issued occupational noise standards to protect workers. Where such State standards are more restrictive than Federal standards, they will apply to geothermal activities in lieu of Federal standards. (Occupational noise standards generally require that workers be equipped with protective devices if noise levels exceed certain levels rather than requiring that the noise levels be reduced.)

Noise levels which may be objectionable to residents adjacent to geothermal lease areas are more difficult to evaluate. In general, a noise is objectionable whenever its level exceeds by a certain margin that of the preexisting background noise, or when it attains a certain absolute level. At present, there are no Federal standards for objectionable noise associated with geothermal activity. As Federal or State government noise standards are formulated, they will apply to geothermal activity as appropriate under Section 270.41 of the operating regulations.

Geothermal development standards have been adopted by Imperial County, California, and have been proposed for several other California counties with prospects for geothermal development. The Imperial County standards include provisions for noise abatement. Although these county standards are not legally applicable to Federal leases, as appropriate such standards will be adopted as lease stipulations or GRO Orders and applied to Federal leases. The Imperial County noise standards are:

<u>Classification of Standards</u>

(a) Class I Standards:

Class I Standards shall apply to any exploratory Geothermal Well, or Geothermal Production Site in Imperial County.

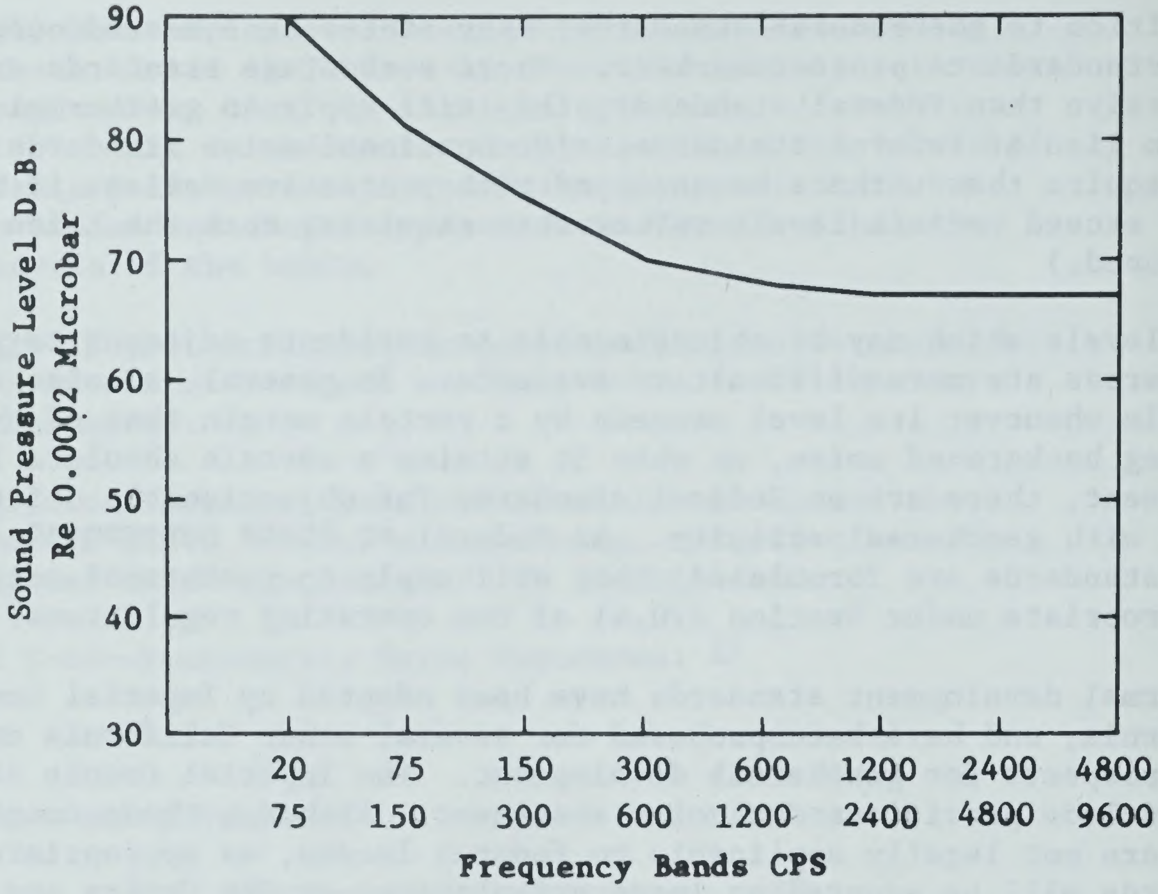
(b) Class II Standards:

Class II Standards shall apply in addition to the Class I Standards, to any Exploratory Geothermal Well or Geothermal Production Site adjacent or near existing development as determined by the Planning Commission.

(c) Class I Drilling Standards:

(1) Each operator shall limit the continuous generation of wide band noise to that shown on the chart. The level shown may be exceeded by 10% if the noise is intermittent and during daylight hours. The noise levels shall be measured at the parcel boundary.

(2) Sound pressure levels shall be measured at the points specified and shall be measured with a sound level meter and associated octave band analyzer conforming to standards prescribed by the United States of America Standards Institute.



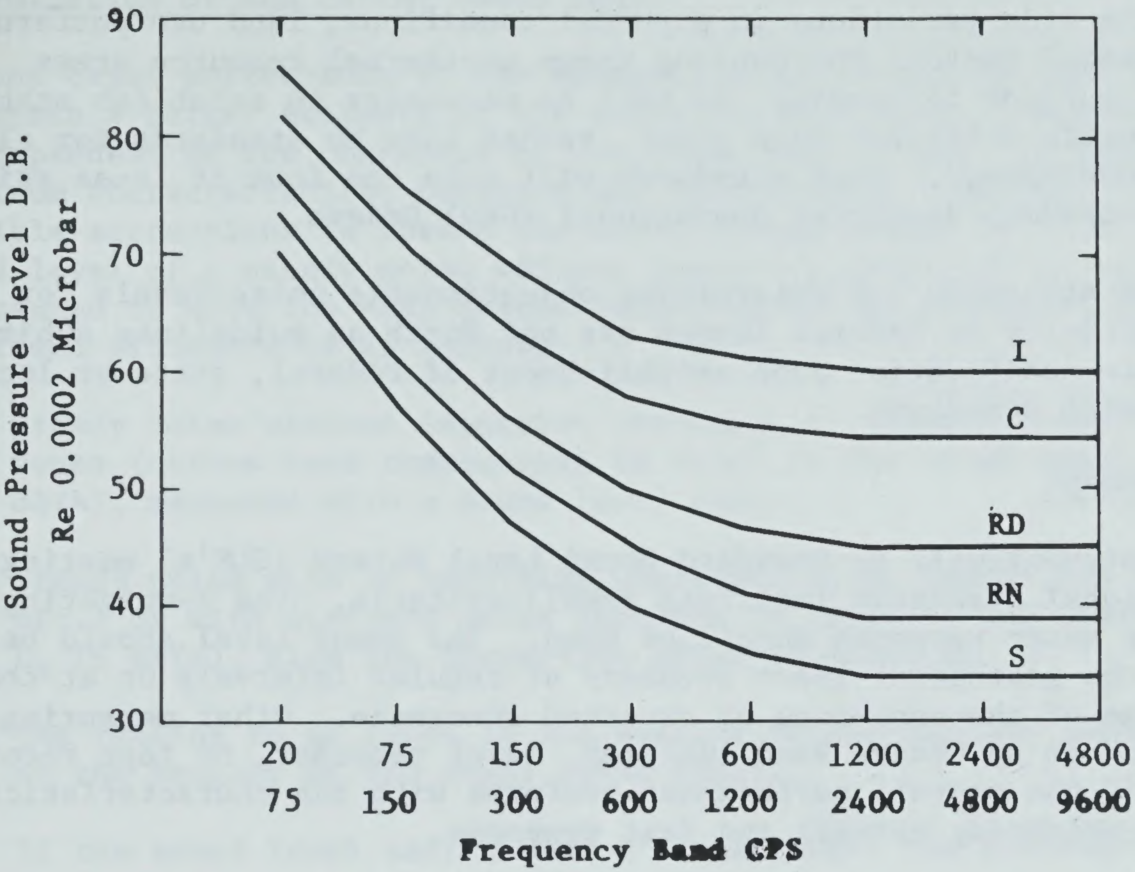
(3) The foregoing graph shall conform to standard units of measurement in accordance with United States of America Standards Institute Code, S-1.11-1966, Appendix A.

(d) Class II Drilling Standards:

(1) All work in preparation of the site for drilling shall be done between the hours of 7:00 a.m. and 7:00 p.m.

(2) The Planning Commission shall direct which Noise Level curve as shown on the chart shall apply. Each operator shall limit the continuous generation of wide band noise to that required. The level may be exceeded by 10% for any one occurrence if the noise is intermittent and during daylight hours.

(3) Sound pressure levels shall be measured at the points specified and shall be measured with a sound level meter and associated octave band analyzer conforming to standards prescribed by the United States of America Standards Institute.



(4) The foregoing graph shall conform to standard units of measurement in accordance with United States of America Standards Institute Code, S-1.11-1966, Appendix A.

(5) No drill pipe shall be racked or made up except between the hours of 7:00 a.m. to 7:00 p.m. Exception to this is allowed where sound proofing is provided or in case of emergency.

(6) Drilling may be on a 24 hour basis providing the above is met.

(e) Class I Production Standards:

(1) All requirements imposed by the Class I drilling standards shall remain in effect.

(2) Continuous and intermittent sound shall be controlled to the levels listed under (c)(2) (Drilling Noise Standards for Class I).

(f) Class II Production Standards:

(1) All applicable requirements imposed by the Class II Drilling Standards shall remain in effect.

(3) Continous and intermittent sound shall be controlled in accordance with paragraph (d)(2) (Drilling Class II).

In view of the wide variations in physical conditions, land use patterns and environmental factors surrounding known geothermal resource areas which may be subject to leasing, it will be necessary to establish standards for objectionable noise for each tract, rather than by standards for all geothermal development. Such standards will take the form of lease stipulation or Geothermal Resources Operational (GRO) Orders.

The following standards for determining objectionable noise levels for geothermal activity on Federal leases are set forth as guidelines subject to appropriate modification upon establishment of Federal, state or local government noise standards.

Noise Measurement

Measuring equipment will be Standard Sound Level Meters (SLM's) meeting American National Standards Institute (ANSI) criteria. The A-weighting network and fast meter response should be used. The sound level should be measured at the geothermal lease boundary at regular intervals or at the place and time of the annoyance or expected annoyance. Other measuring equipment such as an Octave Band Analyzer, level recorder, or tape recorder may be used if the overall performance conforms with the characteristics of a SLM with A-weighting network and fast response.

Measurement Conditions

Outdoor measurements should be made at 3 to 4 feet above the ground and, if practical, at least 10 feet from walls, buildings, or other sound reflecting structures. Measurements made at greater heights or closer to reflecting structures should specify the exact measurement location.

Care should be taken to avoid influence on the measurement from unwanted sound signals, e.g., wind noise from sporadic sources not under consideration and noise from electrical interference.

When noise source is distant, the measured sound may depend significantly on climatic conditions. Extreme conditions of weather should be avoided whenever possible. A typical value and an indication of the variation of the sound level should be obtained.

Indoor measurements should be made at least 3 feet from walls and 4 feet above the floor, and about 5 feet from windows glazed with single strength glass. Sound levels measured indoors should be averaged over at least three positions around the areas of interest. The arithmetic average of the readings determines the value to be used. Measurements should be made with windows closed unless the room is regularly used with the windows open. In this case measurements should be made under both conditions. If the noise is not steady, the level and duration of the noise must be determined. The period of time in which the time history is observed must be chosen according to the character of the variation of the noise. If possible, the period should cover more than one typical variation cycle.

Determination of the Rating Sound Level

In many cases corrections to the measured sound level, L_A, are needed to obtain a better estimate of the objection to noise. The corrections are dependent on the character of the noise with respect to peak level, spectrum characteristics, duration and fluctuation. The sum of L_A and possible corrections is termed the Rating Sound Level, L_r, i.e., the sound level of a steady noise without impulsive character or pure tones is assumed to have the same objectionability as the measured noise. The specified procedure is as follows:

Steady noise without impulsive character or clearly audible pure tones (narrow band components) is rated by the sound level, L_A, in dB(A), measured with a sound level meter.

Steady noise with an impulsive character (like hammering, riveting, etc.) or with discrete noise impulses is rated by the sound level, L_A in dB(a), plus the correction given in Table A.

The reading to be taken is the average of the maximum deflections of the pointer of the sound level meter.

If the sound level varies over a large range, the procedure described for averaging should be used.

Table A - Corrections to the measured sound level in dB(A)

Characteristic features of the noise		Correction dB(A)
Peak	Impulsive noise, e.g., hammering	+5

Steady noise which contains audible pure tone components (whine, screech, hum, etc.) is rated by the sound level, L_A, plus the correction given in Table B.

Table B - Correction to the measured sound level in dB(A)

Characteristic features of the noise		Correction dB(A)
Spectrum Character	Audible tone components, e.g., whine	+5

If the noise is interrupted by pauses (for example, almost unchanging factory noise lasting several hours followed by a pause) a correction according to Table C should be applied to the sound level, L_A, to account for the reduced duration of the noise. The duration of the noise should be reckoned with over a relevant time period. For noise produced by industrial operations or construction the period should be each 8-hour working period.

Table C. Corrections to the measured sound level in dB(A)

Characteristic features of the noise	Correction dB(A)	
Duration of the noise with sound level, L_A, as a percentage of the relevant time period	Between	
	100 and 56%	0
	56 and 18%	-5
	18 and 6%	-10
	6 and 1.8%	-15
	1.8 and 0.6%	-20
	0.6 and 0.2%	-25
	Less than 0.2%	-30

For noise not associated with any regularly occurring scheduled activity for the following periods will be used.

Day: 6:00 a.m. - 6:00 p.m.
Evening: 6:00 p.m. - 12:00 midnight
Night: 12:00 midnight - 6:00 a.m.

If a noise source is to be considered during special conditions, for example, during the weekend, measurements must take into account the conditions during the weekend, for example, by measuring the background noise at the relevant time for establishing the criterion noise level.

If the noise varies with time in a more complicated manner than appropriate for the corrections in Tables A, B, and C, the equivalent sound level, L_{eq}, should be obtained using the method given below.

$$L_{eq} = 10 \log_{10} \left[\frac{1}{100} \sum f_i 10^{L_i/10} \right]$$

Where,

L_{eq} is the equivalent sound level in dB(A) to be used for L_A. L_i is the sound level in dB(A) corresponding to the midpoint of the sound level class i. For example, sound level class 100 extends from 97.5 to 102.5 dB(A). f_i is that time interval (expressed as a percentage of the relevant time period) for which the sound level is within the sound level class i.

The sound level classes should be classed in increments of 5 dB(A) from 0 dB(A) through the class which includes the highest measured level. The relevant time period should be as defined above. After computation of L_{eq} the corrections for impulse and pure tone characteristics should be applied.

Noise Criteria

In general, a noise is objectionable whenever its level exceeds by a certain margin that of the preexisting background noise, or when it attains a certain absolute level. The method of rating noise is based on a comparison of the rating level, L_r, with a criterion level which takes various features of the environment into account. The criterion is related to the preexisting background level, either fixed for a certain zone in general or directly measured for special cases.

Specific Noise Criteria

Noise levels from any geothermal related activity shall not exceed the following industrial noise criteria at the lease boundary line. In addition, noise emitted from any geothermal related activity shall not result in increased noise levels exceeding the following use zone criteria as measured on adjacent properties at the closest point of habitation or use to the geothermal lease line.

Industrial and Geothermal Use

Daytime	70 dB(A)
Evening	65 dB(A)
Night	60 dB(A)

Business and Commercial Use

Daytime	65 dB(A)
Evening	60 dB(A)
Night	50 dB(A)

Residential - Urban	
Daytime	60 dB(A)
Evening	55 dB(A)
Night	45 dB(A)
Residential - Suburban	
Daytime	50 dB(A)
Evening	45 dB(A)
Night	35 dB(A)
Residential - Rural	
Daytime	45 dB(A)
Evening	40 dB(A)
Night	30 dB(A)
Agricultural	
Daytime	70 dB(A)
Evening	65 dB(A)
Night	55 dB(A)
Recreation	
Daytime	45 dB(A)
Evening	40 dB(A)
Night	30 dB(A)
Uninhabited or Rangelands	
Daytime	70 dB(A)
Evening	65 dB(A)
Night	60 dB(A)

The above noise criteria may be exceeded under emergency conditions upon approval of the Supervisor. Noise criteria may also be exceeded if the lessee obtains written permission from all parties affected by the noise which exceeds the above criteria. Complaints from persons to noise levels below the above criteria in excess of 10 percent of the adjacent occupants to the geothermal lease shall cause the Supervisor to review the noise criteria as established and alter such criteria if, in his estimation, such levels should be reduced. The geothermal lessee shall be responsible for taking all measurements in the presence of the Supervisor or his duly authorized representative.

Special Cases

For rating noise in special cases, for example in case of complaints against a certain noise source at a certain place, the background noise level serves as the criterion. The background (ambient) noise is the minimum sound level at the relevant place and time in the absence of the noise which is alleged or expected to offend. It should be obtained by observing the pointer on the sound level meter and by reading the lowest level which is

repeated several times (mean minimum sound level). Statistically background can be defined as the sound level which is exceeded 95 percent of the time.

The background noise level includes appropriately the influences of the type of district, the season, and the time of day. It can be used for noise assessment.

To prevent a creeping (gradually increasing) background noise level, it may be necessary to compare the measured background level with the general criterion as derived above for the relevant zone and time of day. The level chosen will be based on the particular situation, but will usually be the lower of the two.

Assessment of the Noise

In order to assess with respect to the expected objectionability, the rating sound level as obtained will be compared with the criterion value after adjustment for zone and time of day. If the rating sound level exceeds the criterion value by 5 dB(A) the noise is considered objectionable.

Technical efforts at reducing noise emissions from geothermal wells have been directed primarily toward the design of muffling devices (Figure III-8). Experiments at the Otake Geothermal Powerplants located in the Aso Mountains of Japan have shown that an ordinary expansion chamber muffler is not effective for high frequency sound abatement. However, a specially designed muffler effected good noise reduction, even in the high frequency region, and it did not create much resistance to steam flow. These muffler designs and their influence on noise levels are shown in Figures III-9 and III-10.

Measurements were taken using a microphone and 1/3 octave band analyzer at a distance of one meter from the 6-inch diameter steam outlet ejector pipe.

Attenuation of objectionable noise from venting of steam wells can be accomplished through the use of properly designed muffling devices. Other designs have been successfully tested at Cerro Prieto, Mexico, and at The Geysers in California. The venting of steam under water has also proven effective in reducing noise emissions.

Research and development work is also being conducted to reduce noise emission from drill rigs through use of acoustical materials, mufflers, and sound attenuating practices. Many new techniques have resulted and are being applied to current drilling practices. Application of the most up-to-date techniques for reducing all noise related to geothermal activities should be practiced by development companies. GRO Orders or lease stipulations may be issued requiring use of mechanical noise attenuation devices.

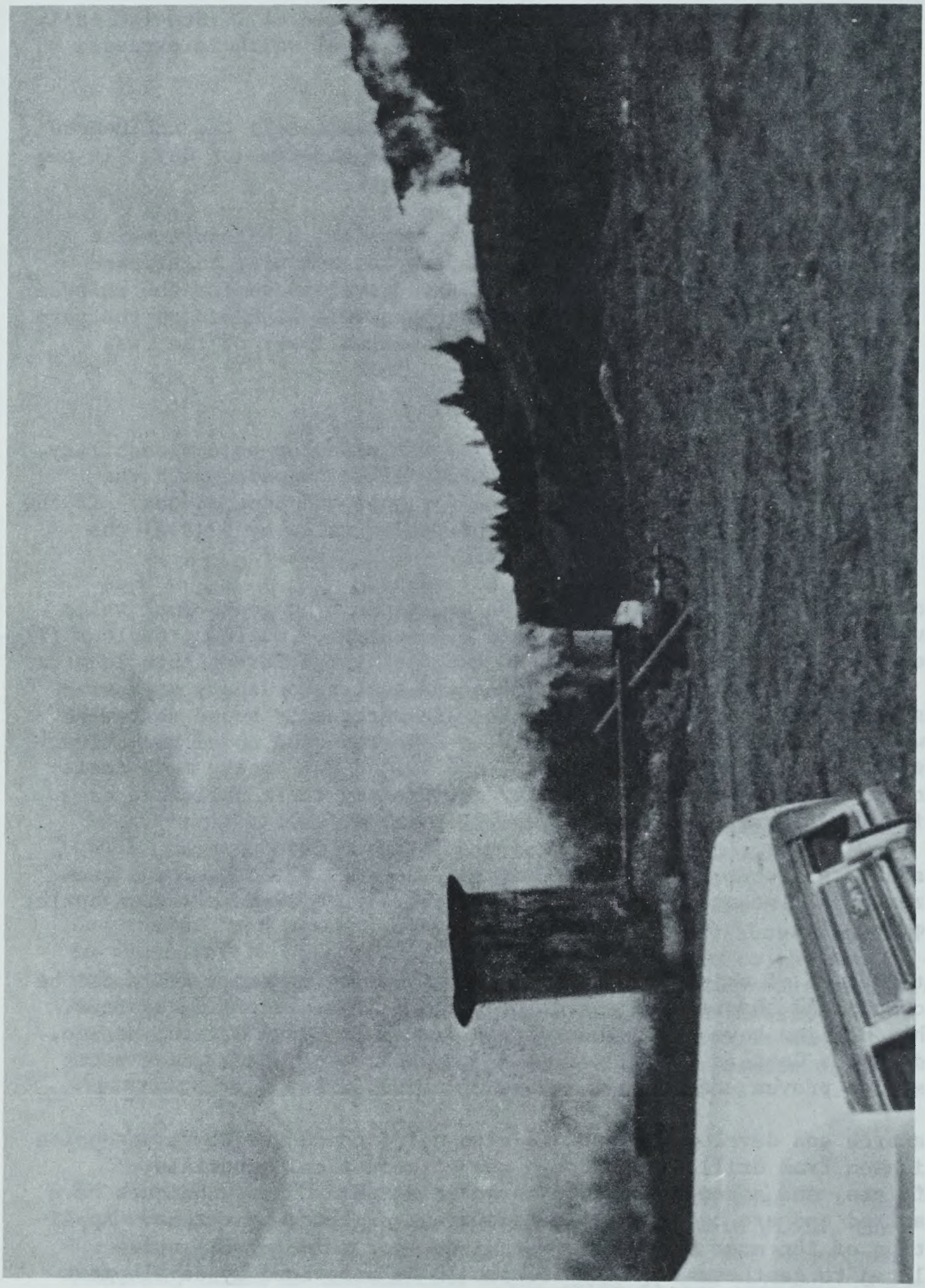


Figure III-8. Vertical design muffler on steam well under development at The Geysers field. Noise is muffled and directed upward,

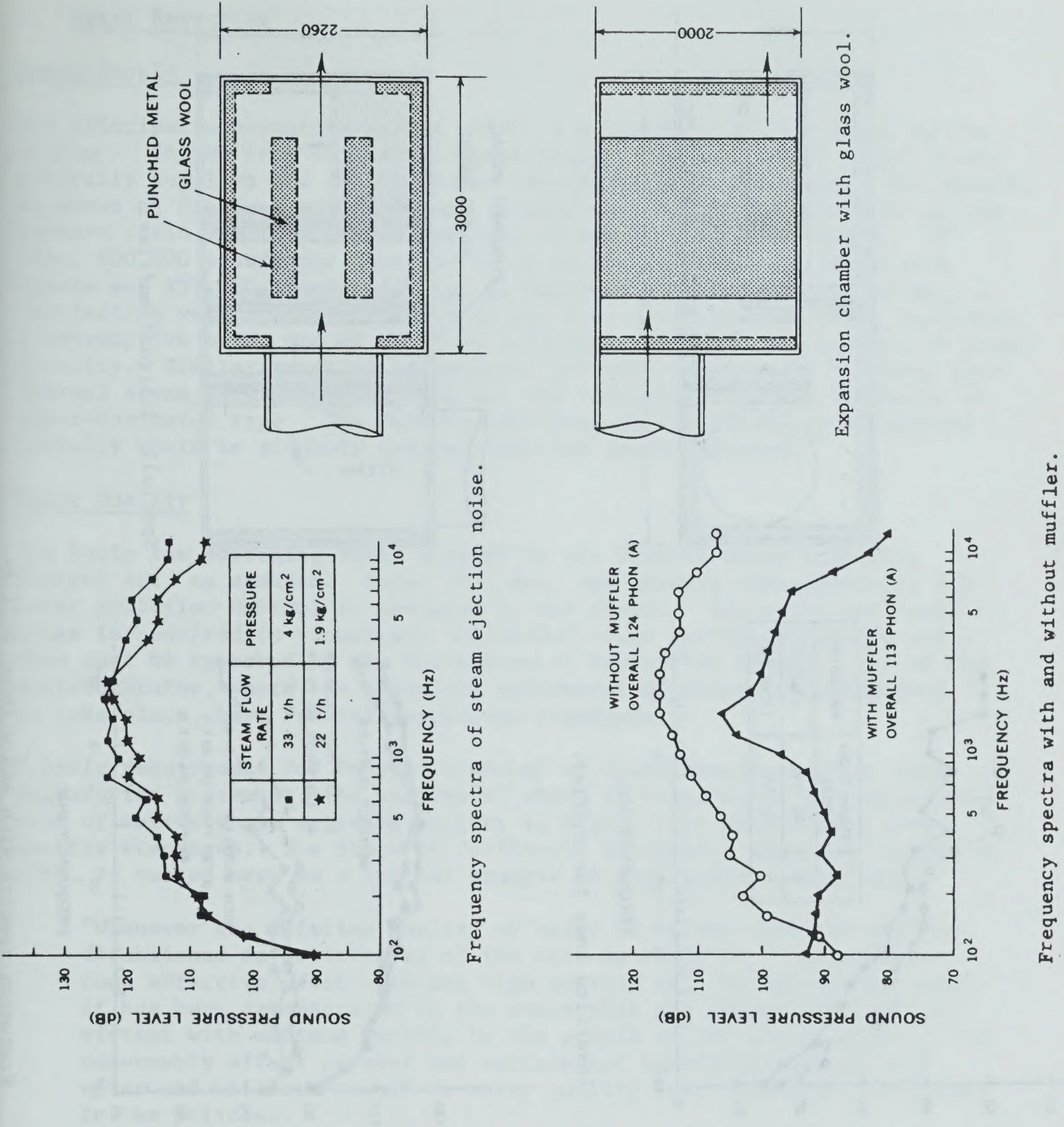


Figure III-9. Noise and design characteristics of expansion muffler
(After Nishiwaki, N., and others, 1970)

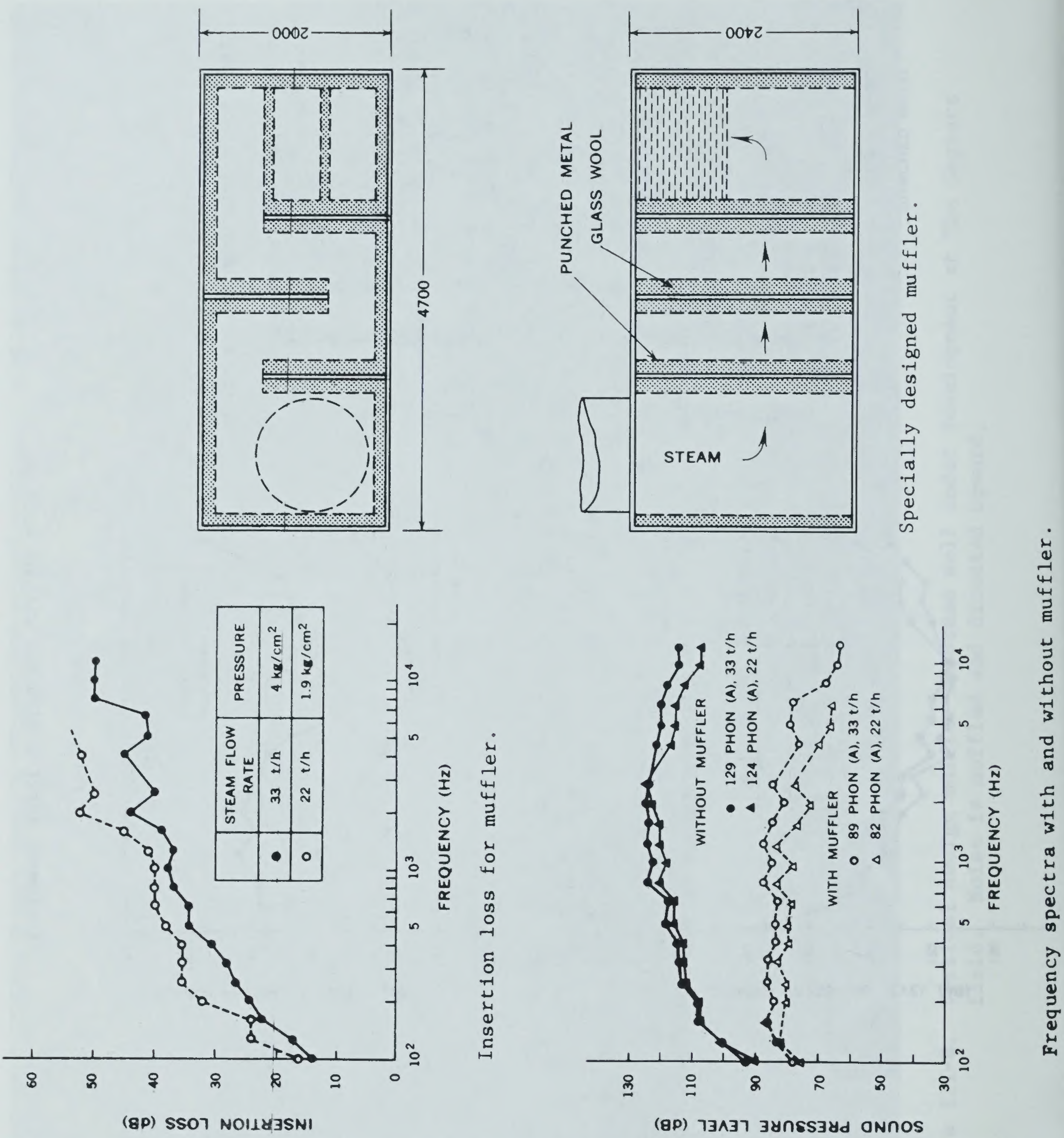


Figure III-10. Noise and design characteristics for experimental muffler (After Nishiwaki, N., and others, 1970)

c. Water Resources

Water Supply

The principal consumptive use of water in a geothermal development is for cooling. In the case of electric powerplants, the geothermal fluid itself generally supplies the cooling water requirements of the plant. For example, as shown on Figure II-12, the heat balance diagram for a 55 MW unit at The Geysers field, 968,060 pounds per hour of steam enters the system. Of this, 800,000 pounds per hour is vented to the atmosphere from cooling towers and 157,630 pounds per hour is returned to the formation through a reinjection well. Converting pounds per hour to volumetric units indicates a consumptive water use of about 46 acre-feet per year per megawatt of plant capacity. Similar rates of consumption probably would apply to other geothermal steam turbine systems whether the resource is of the hot-water or vapor-dominated type. The cooling requirements for binary cycle systems probably would be slightly greater than for steam turbines.

Water Quality

The basic law governing water quality is the Federal Water Pollution Control Act, as amended. Under this Act, the primary responsibility for water pollution control is assigned to the states. Under the Act, each state is required to promulgate intrastate water quality standards which then must be approved by the Environmental Protection Agency. All of the western states, where the principal geothermal development is expected to take place, have Federally-approved standards.

A basic requirement for Federal approval of state standards is an antidegradation statement, the purpose of which is to prohibit the deterioration of waters whose existing quality is higher than established water quality standards. The State of California statement, approved January 9, 1969, is quoted here as a typical example of such policy guidelines:

> "Whenever the existing quality of water is better than the quality established in policies as of the date on which such policies become effective, such existing high quality will be maintained until it has been demonstrated to the state that any change will be consistent with maximum benefit to the people of the state, will not unreasonably affect present and anticipated beneficial use of such water and will not result in water quality less than that prescribed in the policies.
>
> "Any activity which produces or may produce a waste or increased volume or concentration of waste and which discharges or proposes to discharge to existing high quality waters will be required to meet waste discharge requirements which will result in the best practicable treatment or control of the discharge necessary to

assure that (a) a pollution or nuisance will not occur and (b) the highest water quality consistent with maximum benefit to the people of the state will be maintained.

"In implementing this policy, the Secretary of the Interior will be kept advised and will be provided with such information as he will need to discharge his responsibilities under the Federal Water Pollution Control Act." (Function transferred to Administrator, Environmental Protection Agency.)

As the initial geothermal development is occurring in California, that state's system of water quality control will be described herein. The statewide responsibility rests with the State Water Resources Control Board. Regional Water Quality Control Boards carry out the function of water quality control under applicable Federal and state laws. Each Regional Board is responsible for preparation of a Water Quality Control Plan, which sets forth policy guidelines, water quality objectives and discharge prohibitions and a program for implementation and surveillance. With respect to geothermal operations, each operation is considered by the appropriate Regional Board, and an order is issued setting forth waste discharge requirements for the specific operation.

Exhibit III-B, at the end of this section, presents excerpts from the Interim Water Quality Control Plan for the West Colorado River Basin (State Water Resource Control Board, 1971) which embraces the Imperial Valley geothermal area. These excerpts include policy guidelines, water quality objectives and discharge prohibitions.

The effect of these regulations with respect to geothermal development in Imperial Valley is to prohibit discharge of hot waste waters to surface drains or shallow ground water except in the event that such drainage would represent an improvement in the various aspects of the water quality objectives. The general effect of these regulations is to require reinjection of geothermal fluids in a manner that will not result in adverse water quality impacts.

Exhibit III-C, at the end of this section, is an example of a waste discharge order, dated July 13, 1972, covering production, holding and reinjection of brine at Sinclair No. 4, a 5,306 foot-deep well drilled in 1964. The Order illustrates how the Regional Water Quality Control Board manages waste discharge and details its requirements for monitoring. Similar orders would be issued with respect to drilling on Federal lands. Order No. 72-30 specified waste-discharge requirements for a geothermal test well drilled by the Bureau of Reclamation on Federal land in the East Mesa KGRA in the summer of 1972.

Compliance with Section 3204.1(c)(2) and Section 270.41 requires lessees to conduct all operations in compliance with Federal and State Water Quality Standards and appropriate health and safety standards. It further

specifies that toxic materials shall not be released to any surface or underground waters. Reinjection of waste geothermal fluids into geothermal or other suitable aquifers may be permitted upon approval of the supervisor in accordance with the provisions of Public Law 92-500, October 18, 1972.

Radioactivity may present a special question because geothermal waters contain radioactive radon gas and other radionuclides in solution. Such gas normally is separated out of geothermal steam along with other noncondensible gases or may discharge to the atmosphere when hot water is exposed at land surface. (Radon in gaseous form is discussed under Air Quality.) The combined radiation from radon in solution and other radionuclides in geothermal waters in pipes, etc., conceivably could represent a health hazard to workers continuously exposed to such radiation. The maximum permissible concentration (MPC) of unidentified radionuclides in water applicable for continuous exposure (168 hr/wk) as recommended by the National Committee for Radiation Protection (National Bureau of Standards, 1959) is specified as not to exceed 10 microcuries per milliters of water. Where detailed analyses of such waters identify the individual elements present, less stringent MPC limits may apply, depending upon constituent concentrations. However, it should be noted that the MPC cited above is based upon the presumption that 2.2 liters per person per day of such water is ingested over long periods (International Commission on Radiation Protection, 1959) a very unlikely contingency in the case of geothermal fluids.

Water from Sinclair 4 well in the Salton Sea KGRA, drilled to 5,306 feet in 1964, when sampled July 5, 1967, indicated combined net beta and gamma radiation of 550 picocuries per liter (State of California, Department of Water Resources, 1970) or about five times the applicable MPC for unidentified radionuclides in water (100 p c/1). This water would exceed the maximum permissible concentration for continuous exposure to such water (168 hr/wk) as defined above.

Analysis to determine the radioactivity of fluid will be required for each well drilled on Federal leases. If such analysis indicates that a health hazard exists, a GRO Order will be issued requiring adequate health and safety precautions and periodic monitoring as appropriate. If radioactivity should be of such nature that it could not be held to acceptable levels, then production from such wells would not be permitted until new technology or systems were available to assure adequate health and safety protection.

d. Biotic Resources

Because of the wide diversity of vegetative cover, fish and wildlife habitats and populations that could be affected by geothermal development, it is not possible to develop and present a single comprehensive set of mitigating measures that adequately would cover all situations. Accordingly, the proposed leasing regulations can only include adequate provision for inclusion of appropriate protection measures in each lease and its related operational

orders. Section 3204, 1(g) requires that the lessee shall employ such measures as are deemed necessary to protect fish and wildlife and their habitat. Section 3204, 1(i) provides that the lessee shall provide for the restoration of all disturbed lands in an approved manner. Necessary fish and wildlife and land restoration measures will be developed on a site-sensitive basis and included as special stipulations in each lease or as Geothermal Resources Operational Orders.

Land areas to be used for the permit life for generation facilities, roads, etc., would remain cleared with resultant loss of plant cover and wildlife habitat. Other areas subject to temporary use or disturbance would be subject to restoration and, in most instances, it should be feasible to require that such restoration be equivalent to, or better than, the ground cover that previously existed. In some situations it well may be that wildlife habitat could be improved as a result of this process (game travel routes between grass or browse areas, improved forage where grass or shrubs replace nonedible brush, etc.). Much of the disturbed surface vegetation and soil within road, power transmission or steam pipeline routes would be subject to soil stabilization, preparation and seeding with appropriate wildlife food and cover species. Use could be made of either native plants or acceptable or improved substitutes which would equal or improve food values for indigenous wildlife species. Adequate erosion control and drainage measures will be required to mitigate soil movement from disturbed sites and the amount of silt entering water courses. All phases of exploration, development and production operations will be monitored and inspected to insure compliance with lease and GRO Orders. Fish and wildlife population surveillance will be maintained to detect significant adverse trends as a basis for implementation of necessary corrective actions.

Electrocution of eagles, hawks and other birds by contact with power lines will be minimized to the extent possible by avoidance of areas of highest potential contact and through use of techniques set forth in Rural Electrification Administration Bulletin 61-10. Under the provisions of Section 3204, 1(g) of the regulations special provisions will be developed as appropriate to protect these and other wildlife values. Where the threat of significant bird losses exists, particular attention will be directed to the making of whatever actions are needed to minimize such risks. Likewise, precautions will be taken relative to any other significant hazards to fish and wildlife species.

Water quality protection measures, as set forth in the previous section, will provide for adequate protection of fish values and for water-related wildlife factors. While there may be temporary adverse impacts, they can be held to acceptable minimum levels, thereby avoiding serious longer range impacts. Wherever special considerations are involved, appropriate provisions will be included in the lease stipulations or in the related GRO Orders.

Noise levels during drilling, testing and construction could have temporary impact on wildlife. Normally, this would be of relatively short duration and would be more in the nature of a disturbance rather than damage. However,

if there are critical wildlife factors such as nesting seasons, migration routes, etc., special noise control provisions may be required and, in especially critical areas or seasons, it might be necessary to prohibit damaging noise levels. Where such potential exists, each operating area will have to be carefully evaluated and appropriate restrictions imposed.

The opening of new roads and trails may result in additional opportunity for public access which in turn could increase use. Resulting hunting and recreational use could impose additional pressures on fish and wildlife populations. By contrast, geothermal development may curtail some public hunting and recreational uses within the lease tract to assure public safety or to provide security for operations in the immediate vicinity of facilities. Such impacts are not expected to be significant. In the event problems are anticipated or detected, corrective measures would be taken as appropriate.

In addition to the protection afforded by the specific provisions of the Geothermal Resources Operations On Public, Acquired and Withdrawn Lands Regulations (30 CFR, Parts 270, 271) the land management agencies with basic responsibility for the management of public lands will be available to provide assistance to assure that biotic resources on leased areas are adequately protected, managed and used consistent with geothermal uses and with related land and resource values of adjacent areas. While the supervisor is the responsible official for carrying out the provisions of the regulations, he will call upon and use the expertise of Federal land management agencies, other Federal agencies, state and local government personnel, and others, as appropriate for advice and assistance in protecting plant, fish and wildlife resources and values.

Exhibit III-B

Excerpts from Water Quality Control Plan (Interim)
West Colorado River Basin 7-A
California State Water Resources Control Board

POLICY GUIDELINES

GOALS

In view of the limited water resources in the West Colorado River Basin, and the increasing intensity of use of the waters, the policy of the California Regional Water Quality Control Board, Colorado River Basin Region, is to direct its actions toward achieving the following goals.

1. Preserve and enhance the quality of State waters, both surface and underground, fresh and saline, for present and anticipated beneficial uses.
2. Control the quality of wastewater discharges to optimize the reuse of this water resource.
3. Encourage reclamation and reuse of wastewaters, where feasible, in order to preserve fresh water supplies to the maximum extent possible.
4. Preserve the integrity of groundwater basins, so that the basins remain capable of storing water for beneficial use.
5. Seek improvement in the quality of interstate waters entering the Basin.

MANAGEMENT PRINCIPLES

The above goals will be implemented by using the following management principles.

1. Waste treatment and discharge systems are subservient to their main purpose for existence, which is to optimize the quality of State waters, and to optimize reclamation of wastewaters for beneficial use.
2. The optimization of water quality shall be considered in relation to environmental goals.
3. Wastewater treatment and discharge systems shall be directed towards regionalization, but with due consideration to retaining reclaimable wastewaters as far upstream as is feasible.
4. Land use practices shall be controlled to assure preservation of the integrity of usable groundwater basins.
5. Source control and pretreatment of wastes shall be optimized to minimize degradation of water quality by toxicants, biostimulants, and filtrable substances.
6. The transport of hazardous materials shall be controlled to prevent spillage and leakage.
7. Wastes which have long-term capability of polluting waters shall be discharged in such manner and locations as to be protected against erosion or inundation from a maximum storm which could be expected to occur on a frequency of at least once in a 100-year period.
8. The discharge of untreated sewage into New River from the City of Mexicali, Mexico, must cease.
9. The administration of grants and loans to sewerage entities shall include determination of implementation of adequate source control and industrial waste ordinances.

Exhibit III-B

(continued)

10. Groundwater recharge with water of adequate quality is encouraged.

11. Evaporative loss of reclaimable wastewater is to be minimized.

12. The primary purpose of Salton Sea is to receive natural and agricultural drainage and seepage waters.

WATER QUALITY OBJECTIVES AND DISCHARGE PROHIBITIONS

Many water quality terms and expressions are generally understandable. However, there are several terms which ought to be specifically defined. The definitions of these latter terms are as follows:

Water Quality is the set of chemical, physical and biological properties which affect the use of water.

Water Quality Indicators are constituents or characteristics which serve to measure water quality. Examples of indicators are: Temperature, dissolved oxygen (DO), biochemical oxygen demand (BOD), pH, Chloride, bacteria, and appearance.

Certain water quality indicator terms are not sufficiently self-explanatory and are therefore further defined below, as follows:

> **Pesticide** is any substance or mixture of substances used to control objectionable insects, weeds, rodents, fungi, or other forms of plant or animal life.
>
> **Biostimulant** is any substance which stimulates or increases the growth of aquatic organisms: examples are nitrogen and phosphorus.
>
> **Toxicity** is the poisonous effect of organic or inorganic substances or combination of these substances upon animal or plant life.

Water Quality Objectives are limits or levels prescribed for water quality indicators for protection of indicated uses.

The following list of general water quality objectives are applicable to all ground and surface waters in West Colorado River Basin.

1. **COLOR** – No significant increase beyond background* levels.

2. **TURBIDITY** – No significant increase beyond background levels.

3. **BOTTOM DEPOSITS** – None other than from background origin.

4. **FLOATABLES, OIL, AND AGREASE** – No visible effect other than of background origin.

5. **ODORS** – None other than of background origin.

6. **PESTICIDES** – The total summation of concentrations of individual pesticides in surface waters shall not be greater than 0.1 micrograms per liter. Nor shall concentrations of pesticides be allowed that are detrimental to fish and wildlife. Exception is allowed in those irrigation canals which do not have appreciable aquatic resources, and where short-term herbicide operations are conducted under irrigation district supervision in coordination with the State Department of Fish and Game.

7. **pH** – No significant change in normal ambient value; nor shall the pH be depressed below 6.5 units, or raised above 8.5 units as a result of waste discharges.

---

*Background is that status of a particular body of water which is incident to the established natural, agricultural, or river control conditions or to established combination of conditions.

8. **BIOSTIMULANTS** – No substance shall be added which produces aquatic growths in the receiving waters to the extent that such growths cause nuisance or damage to any of the beneficial water uses.

9. **COLIFORM BACTERIA** – As recommended by the California State Department of Public Health for these waters.

10. **TOXICITY** – No toxic substance which will produce deleterious effects upon aquatic biota, humans, or wildlife, or that create undesirable tastes or odors in the waters or in fish, wildlife, or agricultural stock flesh shall be discharged to the receiving waters.

11. **RADIOACTIVITY** – Radionuclides shall not be present in concentrations that exceed the maximum permissible concentration for radionuclides in water as set forth in Chapter 5, Title 17, of the California Administrative Code. The objective shall be to minimize radioactivity to the extent physically and economically feasible.

12. **TEMPERATURE** – The temperature objectives of Interstate Waters shall be as set forth in the policy regarding the "Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California," adopted by the State Water Resources Control Board January 7, 1971. Irrigation return water is not considered an elevated temperature waste discharge for the purpose of this policy.

Waste discharges shall not cause the temperature of the receiving water to increase by more than 5°F. in streams or lakes having a range of temperatures generally suitable for warm water fishes such as bass or catfish. Irrigation return water is not considered an elevated temperature waste discharge for the purpose of this policy.

Waters serving a cold water biota shall be maintained free of temperature changes as result of waste discharges.

13. **DISSOLVED OXYGEN** – Median dissolved oxygen concentrations in the main water mass of streams and above the thermocline in lakes shall not fall below 85 percent of saturation concentration, and the 95 percentile concentration shall not fall below 75 percent of saturation concentration as a result of waste discharge.

Additionally, dissolved oxygen at any location shall not fall below 6 mg/l at any time as the result of waste discharges. Nor shall waste discharges cause the dissolved oxygen content in waters designated as spawning and nursery areas, and cold-water biota and trout habitat to fall below 7 mg/l at any time. When background factors cause lesser concentrations, then controllable water quality factors shall not cause further reduction.

14. **DISSOLVED SOLIDS** – No dissolved solids shall be added in quantities found to be deleterious to the beneficial uses.

The criteria for defining levels of specific water quality indicators used in prescribing waste discharge requirements to achieve water quality objectives is based upon the following:

Exhibit III-B

(continued)

UNITED STATES PUBLIC HEALTH SERVICE DRINKING WATER STANDARDS, 1962		
	In milligrams per liter	
Substance	Recommended limits of concentrations*	Mandatory limits of concentrations
Alkyl benzene sulfonate (ABS)	0.5	–
Arsenic (As)	0.01	0.05
Barium (Ba)	–	1.0
Cadmium (Cd)	–	0.01
Carbon chloroform extract (CCE)	0.2	–
Chloride (Cl)	250	–
Chromium (hexavalent) (Cr^{+6})	–	0.05
Copper (Cu)	1.0	–
Cyanide (CN)	0.01	0.2
Iron (Fe)	0.3	–
Lead (Pb)	–	0.05
Manganese (Mn)	0.05	–
Nitrate (NO^3)	45	–
Phenols	0.001	–
Selenium (Se)	–	0.01
Silver (Ag)	–	0.05
Sulfate (SO_4)	250	–
Total dissolved solids (TDS)	500	–
Zinc (Zn)	5	–

UNIVERSITY OF CALIFORNIA CRITERIA FOR IRRIGATION WATERS			
Factor	Class 1 – Excellent to good	Class 2 – Good to Excellent	Class 3 – Injurious to unsatisfactory
Electrical conductance, EC x 10^6 at 25°C	Less than 1000	1000–3000	More than 3000
Boron, ppm	Less than 0.5	0.5–2.0	More than 2.0
Chloride, ppm	Less than 175	175–350	More than 350
Percent sodium	Less than 60	60–75	More than 75

Exhibit III-B

(continued)

NORMAL RANGE OF MINERAL PICKUP IN DOMESTIC SEWAGE*	
Mineral Constituent	Normal range, in parts per million (except as noted)
Total dissolved solids (TDS)	100–300
Boron (B)	0.1–0.4
Percent sodium (%Na)	5–15**
Sodium (Na)	40–70
Potassium (K)	7–15
Magnesium ($MgCO_3$)	15–40
Calcium ($CaCO_3$)	15–40
Total Nitrogen (N)	20–40
Phosphate (PO_4)	20–40
Sulfate (SO_4)	15–30
Chloride (Cl)	20–50
Total alkalinity ($CaCO_3$)	100–150

SPECIFIC OBJECTIVES

Explanation of New and Alamo River Source Waters

The source water of Alamo River and of New River is supplied predominantly from the use of these channels as collectors and transporters of control and drainage (including subsurface) waters from irrigated lands in Imperial Valley. This is their primary beneficial use; and this use does not unreasonably affect the quality of the waters of the state.

The objective is to protect the quality of this "source water" from degradation by unreasonable impairment (1) by pesticidal wastes from any source, and (2) by other industrial wastes, or by sewage. The term "other industrial wastes" as used hereafter means all industrial wastes other than the industrial wastes consisting of "control and drainage (including subsurface) waters from irrigated lands in Imperial Valley.

Listings of Specific Objectives

Waste discharges shall not cause the 20 C BOD and the total filtrable residue (TFR) concentration of the following waters to exceed the levels shown below:

Stream	20° C BOD_5	Total Filtrable Residue Average	Total Filtrable Residue Maximum	Units
New River	2	4000	4500	mg/l
Alamo River	2	4000	4500	mg/l
Imperial Valley Irrigation Drains	2	4000	4500	mg/l
Coachella Valley Irrigation Drains	2	1800	2000	mg/l

* Adopted from State Water Pollution Control Board Publication No. 9, Chart 1–8, page 25
**In Percent.

Giving due allowance for the primary purpose of Salton Sea, as explained in Chapter III, the objective is to limit the rate of increase of the total filtrable residue content of Salton Sea water to the lowest possible value.

WATER QUALITY OBJECTIVES FOR SOLID WASTE AND SLUDGE WASTE DISPOSAL

The following objectives are established for the control of water pollution with respect to land disposal of solid or sludge-type wastes.

1. Classification of Solid Waste Disposal Sites

Class 1 Sites

Sites located on nonwater-bearing rocks or underlain by isolated bodies of unusable groundwater, which are protected from surface runoff so that they will not be eroded or inundated by a maximum storm which would be expected to occur on a frequency of at least once in a 100-year period, and where safe limitations exist with respect to the potential radius of infiltration.

Class 2 Sites

Sites underlain by usable, confined, or free groundwater, where the discharge surface can be maintained at least six (6) feet above anticipated high groundwater elevation, and which will not be eroded or inundated by a maximum storm that would be expected to occur on a frequency of at least once in a 100-year period.

Class 2 (special) Sites

Sites which meet all of the objectives for Class 2 sites, as described above, and in addition, are geologically, hydrologically, topographically, and otherwise satisfactory for discharge of specified quantity of a specific waste.

Class 3 Sites

Sites so located as to afford little or no protection to usable waters of the State.

2. Nature of Wastes Acceptable for Discharge at Each Class of Disposal Site

The listing below is not intended to be comprehensive, but rather is provided to indicate the the nature of wastes acceptable at each class of disposal site. Where there is question concerning the nature of a particular waste, the determination will be made by the Regional Board's Executive Officer.

Wastes Acceptable at Class 1 Sites

No limitation as to solid or sludge wastes.

Wastes Acceptable at Class 2 Sites

All wastes excepting

(a) Liquid and/or soluble industrial wastes
(b) Toxic ash
(c) Chemical and pesticide containers

The usual materials acceptable at these sites are household and commercial refuse and rubbish, garbage including tin cans, and other decomposable organic refuse.

Exhibit III-B

(continued)

Wastes Acceptable at Class 2 (special) Sites

Selected wastes of the above-listed prohibition for Class 2 sites. Each waste material will be considered separately as to type and quantity for discharge.

Wastes Acceptable at Class 3 Sites

Limited to nonwater soluble, nondecomposable, inert solids.

PROHIBITIONS

Whitewater Hydro Unit

1. The discharge of natural geothermal waters of the Miracle Hill Subarea outside of the Subarea is prohibited.
2. The use of surface streams, including irrigation drainage streams to dilute and/or treat wastewater discharges is prohibited.
3. The extension of sewer collection systems across Jefferson Street is prohibited.

Imperial Hydro Unit

New and Alamo Rivers and other Irrigation Drains

1. Discharge of wastes which may reasonably be expected to contain pesticides, and particularly the discharge of pesticidal wastes from pesticide manufacturing, processing, or tank-cleaning operations towards these waters is prohibited.
2. Discharge of wastes, whose total filtrable residue concentration exceeds the following values, towards these waters is prohibited. This prohibition shall not be bypassed by diluting the wastes.

Occurrence	TFR (mg/l)
Average	4000
Maximum	4500

3. Notwithstanding the above TFR limitation, the discharge of wastes whose TFR level is unreasonably concentrated in relation to that of the beneficial use(s) being obtained from the Colorado River water is prohibited.
4. Discharge of wastes, whose suspended matter and 5-day 20° C. biochemical oxygen demand (20°C BOD_5) as determined on unfiltered samples exceeds the following limits, to irrigation drains (not including direct discharges to New River and Alamo River), is prohibited.

Exhibit III-B

(continued)

Constituent	Unit	Median	Limiting Values 80 Percentile	Maximum
Suspended Matter	mg/l	20	30	-
20° C BOD_5	mg/l	20	30	40

Where necessary in specific cases, more strict limitations will be placed upon the suspended solids and/or 20° C BOD_5 of specific discharges.

Salton Sea

1. Discharge of sewage (whether treated or untreated) to Salton Sea is prohibited.

2. Subsurface discharge of sewage within 100 feet laterally from the anticipated high shoreline of Salton Sea or at any other location which might result in effluent channelling to Salton Sea is prohibited.

3. The discharge of wastes, whose total filtrable residue concentration exceeds the following values, towards Salton Sea is prohibited. This prohibition shall not be bypassed by diluting the wastes.

Occurrence	TFR (mg/l)
Average	4000
Maximum	4500

4. Notwithstanding the above TFR limitation, the discharge of wastes whose TFR level is unreasonably concentrated in relation to the beneficial use(s) being obtained from the Colorado River water or other water source is prohibited.

5. Discharge of sewage to New River or Alamo River which is not preceded by treatment at least sufficient to result in substantially complete removal of settleable and floatable materials is prohibited.

Exhibit III-C

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
COLORADO RIVER BASIN REGION

ORDER NO. 72-50

WASTE DISCHARGE REQUIREMENTS
FOR
GEOTHERMAL ENERGY AND MINERAL CORPORATION
North of Westmorland - Imperial County

The California Regional Water Quality Control Board, Colorado River Basin Region, finds that;

1. Geothermal Energy & Mineral Corporation, Thomas H. Denman, President, hereinafter referred to as GEMC, 701 Lyerly Road, Calipatria, California 92233, submitted a report of waste discharge dated May 26, 1972.

2. GEMC proposes to discharge 1.2 MGD of brine from Sinclair Geothermal Well No. 4 in the SE¼, Section 4, T12S, R13E, SBB&M. The well will be operated for a period of approximately 90 days and will discharge into a 17-acre holding basin. A 22-acre holding basin will be used, if needed, for emergency overflow. The well will be shut off when the depth of brine in the 17-acre holding basin reaches an average depth of approximately three feet. Residual salts remaining in the basins after evaporation of excess water will provide GEMC with a year's supply of brine and will be disposed of in one of the following ways:

    a. Material will be sold commercially.
    b. Wastes will be discharged at a solid waste disposal site which is approved by the Regional Board to receive this type of material.
    c. Wastes will be reinjected into the production well.

3. The Interim Water Quality Control Plan for the West Colorado River Basin was adopted on June 10, 1971; and this Order implements the objectives stated in the Plan.

4. The beneficial uses of ground and surface waters in the vicinity of the waste discharge are:

    a. Shallow groundwaters are too saline to be beneficially used.

    b. Surface waters contained in irrigation drains are a source of replenishment for Salton Sea. The beneficial uses of Salton Sea that may be directly affected are aquatic and wildlife resources and water contact sports.

Exhibit III-C

(continued)

5. The Board has notified the discharger and interested agencies and persons of its intent to prescribe waste discharge requirements for the proposed discharge.

6. The Board in a public meeting heard and considered all comments pertaining to the discharge.

IT IS HEREBY ORDERED, Geothermal Energy and Mineral Corporation shall comply with the following:

A. Discharge Specifications

1. Neither the treatment nor the discharge shall cause a pollution or a nuisance.

2. Temporary discharge and/or storage of geothermal materials, other than into the reported 22 and 17-acre holding basins, is prohibited.

3. There shall be no seepage or overflow from the holding basin facilities.

4. Geothermal wastes shall not enter Salton Sea, canals, drains (including subsurface drainage systems), or any subsurface strata which could provide flow or seepage to Salton Sea.

5. The discharge shall terminate not later than ninety (90) consecutive days after its inception on or before September 1, 1972.

6. The discharge shall not exceed 1.2 million gallons per day.

7. All seepage from the holding basins shall be intercepted and discharged back into said basins.

8. A minimum freeboard of at least three feet shall be maintained in the holding basins.

9. Adequate protective works and maintenance shall be provided to assure that facilities will not become eroded or otherwise damaged so as to threaten discharge towards Salton Sea.

10. By not later than December 1, 1973, all geothermal materials shall be removed from said holding basins, and shall either be injected into the production well, or otherwise discharged in compliance with Board requirements.

Exhibit III-C

(continued)

B. Provisions

1. GEMC shall comply with the "Monitoring and Reporting Program No. 72-50" and the "General Provisions for Monitoring and Reporting", and future revisions thereto, as specified by the Executive Officer.

2. Transport of liquid wastes shall be in accordance with the provisions of Article 2 of Chapter 1 of Division 7.5 of the California Water Code; and in accordance with rules and regulations contained in Subchapter 13 of Chapter 3 of Title 23 of the California Administrative Code.

3. Prior to the discharge of any geothermal materials into said basin, the discharger shall submit to the Regional Board, a certificate signed by a California Registered Civil Engineer stating that the basins and attendant facilities are constructed to meet the requirements contained in this Order, and to otherwise prevent discharge towards Salton Sea.

I, Arthur Swajian, Executive Officer, do hereby certify the foregoing is a full, true, and correct copy of an Order adopted by the California Regional Water Quality Control Board, Colorado River Basin Region, on JUL 13 1972.

Arthur Swajian

Executive Officer

Exhibit III-C

(continued)

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
COLORADO RIVER BASIN REGION

MONITORING AND REPORTING PROGRAM NO. 72-50
for
GEOTHERMAL ENERGY AND MINERAL CORPORATION
North of Westmorland - Imperial County

Location: SE¼, Section 4, T12S, R13E, SBB&M

MONITORING

Geothermal Energy and Mineral Corporation shall report to the Regional Board concerning the following:

Vail 4A Drain

The waters contained in Vail 4A Drain shall be monitored at its intersection with Lindsey Road and at a point 200 feet below the most northerly brine containment basin for the following:

Constituent	Units	Reporting Frequency
Total Filtrable Residue	mg/l	(a) Twice-monthly, during 90-day production period. (b) Monthly thereafter, until Specification No. 10 is complied with.

Other Reports

Item	Units	Reporting Frequency
1. Discharge to storage basins	Gallons	Monthly
2. Volume injected into subsurface strata	Gallons	Monthly
3. Volume discharged at Regional Board approved disposal site	Gallons or Tons	Monthly
4. Date of commencement of discharge to holding basins.		
5. Date of ending of ninety (90) day discharge period.		
6. Date each injection begins.		
7. Date each injection ends.		
8. Zone or zones used for injection of wastes.		
9. Report on completion of final cleanup.		

Exhibit III-C

(continued)

REPORTING

Monthly reports shall be submitted to the Regional Board by the 15th day of the following month at the following address:

California Regional Water Quality Control Board
Colorado River Basin Region
P.O. Drawer I
Indio, CA 92201

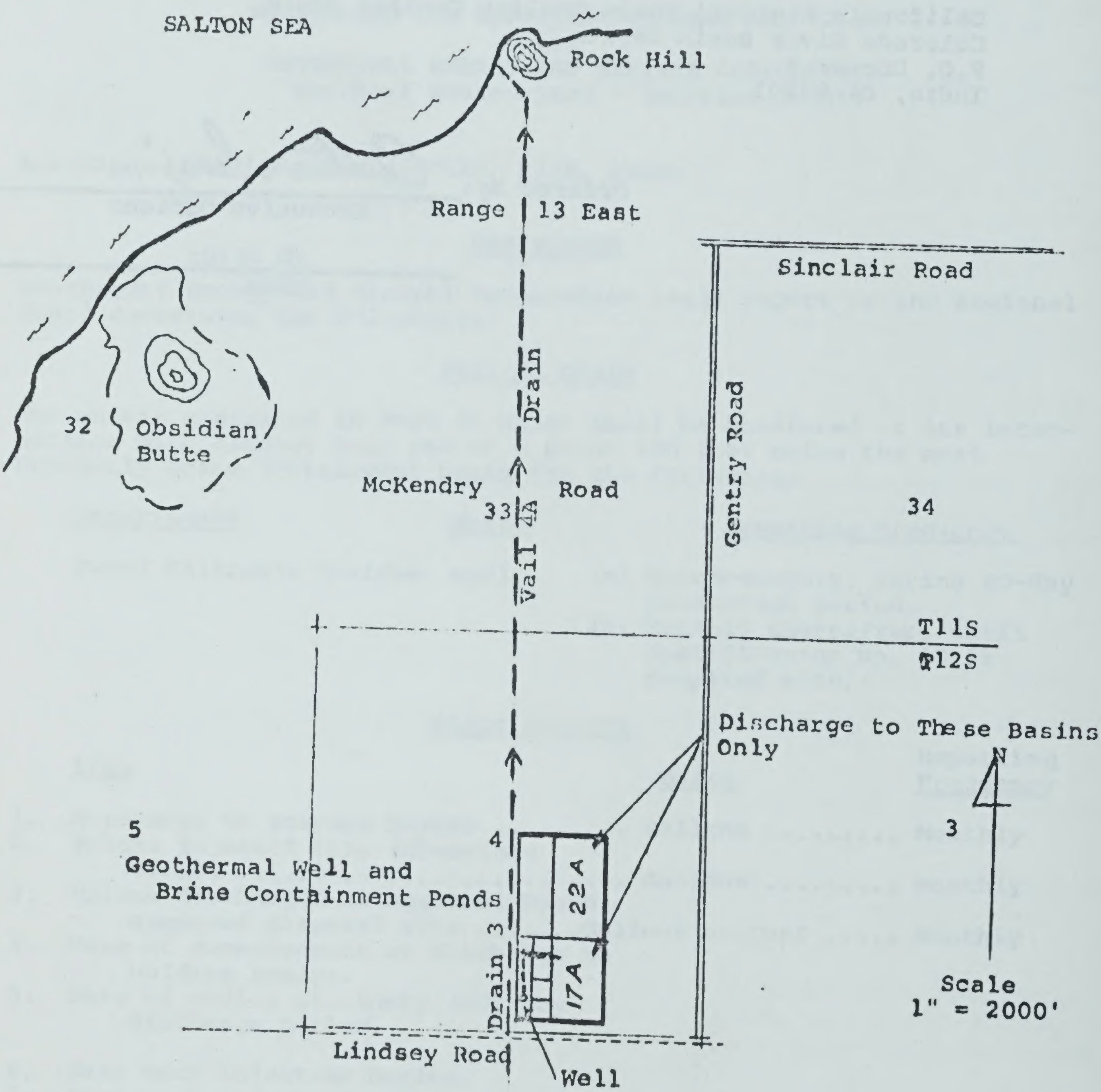
Ordered by: Arthur Swajian
Executive Officer

JUL 13 1972
Date

Exhibit III-C

(continued)

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD - 7



SITE MAP

GEOTHERMAL ENERGY AND MINERAL CORPORATION
Location of Geothermal Facilities

SE¼, Section 4, T12S, R13E, SBB&M

March 22, 1972

D. ADVERSE IMPACTS WHICH CANNOT BE AVOIDED SHOULD THE PROPOSAL BE IMPLEMENTED

The Geothermal Steam Act requires that the Secretary of the Interior promulgate rules and regulations as he may deem appropriate to carry out the provisions of this Act (PL 91-581, Sec. 24). While no environmental impacts result directly from the issuance of such regulations, impacts will result from implementation of pre-leasing, leasing, and operational activities. Potential impacts and mitigating measures associated with such activities have been discussed in the preceding sections.

The rules and regulations, lease provisions, and General Resources Operational Orders are designed to assure that geothermal resources are developed and utilized in an environmentally acceptable manner. In those instances where this cannot be done, development and use will not be permitted. However, virtually any human use of lands and their resources may have some degree of adverse impact. Where benefits warrant acceptance of minor impacts, such uses may be appropriate, provided the adverse impacts have been adequately recognized, mitigated to the extent possible, and are not so serious as to preclude the proposed action. The following discussion summarizes the type of adverse impacts that may be unavoidable should the proposal be implemented.

1. Exploration Phase

Exploration activities will involve physical presence upon the land which may result in damages to the land and resources thereon. Exploration activities include, but are not limited to, geophysical operations, drilling of shallow temperature gradient wells, construction of access roads or trails, and cross-country transit by foot, animals, or vehicles.

Even though persons conducting exploration operations comply with all of the general and specific terms and conditions of the "Notice of Intent to Conduct Exploration Operations," including the restoration of areas as near as possible to their original condition, some adverse impacts still may result. Examples are:

(a) Vehicle travel will result in dust, exhaust gases, noise, disturbande of wildlife, injury or killing of livestock or wildlife, accidents, etc. When existing roads are used, such impacts would be nominal since they primarily would be the result of increased traffic. Advance approval will be required for construction of new roads or trails to assure proper construction and restoration. However, there will be a certain amount of disturbance of vegetative cover and soil surface from cross-country travel on roads or trails that can have temporary impacts until cover is restored and the soil is stabilized. Evidence of such roads or trails may remain for several years which could be conducive to casual use by others that could result in damage. Failure to comply with regulations or exploration stipulations could result in similar impacts but damages could be more significant, particularly if such improper use was not promptly detected and corrected.

(b) Drilling of shallow holes or blasting may be necessary which may result in minor vegetative and surface disturbance in the immediate area of activity. All drill holes will be small and shallow and are to be capped when not in use so no damage is anticipated from such holes. If not capped, small animals could fall into the holes and perish.

(c) The presence of men and equipment will present an additional fire risk in areas of high fire hazard. Even though operators are required to make every reasonable effort to prevent, control or supress fires started by their operations, there can be accidents, human error or carelessness, equipment faults or failures, etc. which could result in fires that could have serious environmental consequences. Similar risks are associated with virtually any human use of areas subject to serious grass, brush, or forest fires.

2. Test Drilling Phase

Following award of leases, heavy equipment capable of drilling to depths of several thousand feet would be required. The enlargement and improvement of existing roads or construction of new roads to provide access for drilling equipment and supplies to the drilling site would involve unavoidable impacts from vegetative cover removal, surface disturbance, cuts and fills for roadbed, soil erosion and siltation during construction and, to a lesser degree, some impacts even after banks were stabilized, vegetative cover was restored, and adequate drainage was installed. At each drilling site a level area of approximately one-half to one acre is required for drilling operations. In hilly country this could necessitate considerable grading. While compliance with lease and GRO Orders will prevent serious adverse impacts, some minor impacts still will result. Most of the potential impacts listed under exploration could be expected with some intensification in areas of heavy activity.

During grading and drilling operations, moderate levels of noise from equipment operations would be unavoidable. Even where special noise control measures are required, noise levels will be above natural levels.

Physical land modification will be greater at this stage which could result in loss of wildlife forage and wildlife values in the areas of operation. Such impacts generally would be of a temporary nature. Some siltation or other degradation of surface waters may result from clearing and earth moving or from drilling operations which could result in localized damage to fish and wildlife. There could be some reduction of public use of areas for recreation, hunting, etc. during periods of test drilling activities to protect equipment and facilities and to reduce hazards to the public. Surface disturbance scars would be larger and possibly permanent in nature.

Well blowouts could result in significant venting of steam, associated gases and brackish water to the atmosphere, ground area and surface water, creating air and water contamination as well as high noise levels and exposing individuals to possible injury.

While modern drilling techniques are capable of preventing such accidents, there is still the possibility they may happen due to human error, equipment failure, or other factors. Adverse impacts would continue until the blowout is controlled. The seriousness of the incident could range from minor to serious, depending upon location, nature of geothermal emissions, duration of blowout, natural resource and environmental values proximate to the area, etc. Blowouts also could result from subsequent events such as earth slides, seismic action, vandalism, etc.

3. Production Testing Phase

The most significant feature of production testing of vapor dominated systems is the release of high volumes of steam for periods of as long as several weeks or even months. This is necessary until the flow stabilizes at a uniform level. During this period the noise impact and gaseous emissions would be at their maximum level. The degree of noxious gas released to the surrounding atmosphere would depend upon the composition of the steam. Release of steam that contains hazardous toxic levels would not be permitted, but less than toxic condensations still could have odor or other adverse impacts. Noise could disturb wildlife or people.

In water-dominated reservoirs, production testing likewise requires production of the formation fluid over an extended period. Disposal of produced water could have an environmental impact if the water containing salts or other toxic substances should be released to the surface environment. Large volumes of liquids could be involved. If not properly contained or reinjected, they could seriously impact on surface water quality and related fish, wildlife, or other water-related values.

4. Full-Scale Operation Phase

Full-scale operation will require complete development of well and steam transmission systems, power generation facilities, transmission lines, permanent roads, etc. Many of the potential adverse impacts associated with exploration and testing will no longer exist but other impacts may increase in proportion to the scale of development. Currently about 10 wells are needed to supply each generating station. Each well will involve clearing, grading, and improvements. Steam pipelines connecting wells to the generators likewise require clearing and grading. During construction there will be considerable activity, noise, movement of earth, dust, etc. After construction is completed and all necessary environmental protection measures are taken, the nature of the site will be changed from its former state to an industrial complex. Cuts, fills, clearings, buildings, power lines, etc. will represent permanent changes in the landscape and affect aesthetic quality. Many recreation activities, particularly hunting and off-road vehicle use, will be eliminated from the industrially developed areas. However, the actual acreage occupied by these areas is not expected to be large.

Other recreation activities such as overnight camping lose much of their quality if they are carried out within sight or sound of the industrial

atmosphere created by geothermal development. The effect would be more pronounced in open grassland and desert areas where visibility is great and sound carries for long distances.

Even with adequate controls, full-scale operations will involve higher than natural noise levels, emission of steam and other gases to the atmosphere, disturbance from operational activities, additional vehicle traffic, etc. Transmission lines will be a hazard to some wildlife as they may result in minor levels of electrocution of eagles, hawks, and other birds. Transmission lines damaged from storms or other failures can result in fires or personal injury but to no greater extent than lines built in connection with other power systems under similar conditions.

Potential adverse impacts would be introduced during full-scale operation from possible land subsidence or increased seismic activity. However, a significant impact from these causes would not be expected until major production begins.

Land subsidence occurs because of compaction of the reservoir materials as fluid is removed and reservoir pressure decreases. This is a consequence of fluid production followed by some compaction in a confined system with substantial pressure decline. The amount and distribution of subsidence is a function of pressure decline and physical character of the reservoir materials, especially their compressibility. Land subsidence due to fluid withdrawal occurs mainly in areas of poorly consolidated sedimentary rocks. Areas underlain by well-indurated sedimentary rock and crystalline igneous and metamorphic rocks generally are not subject to significant compaction and subsidence. Once subsidence occurs, it cannot be reversed, even by fluid injection. Water storage capacity would be correspondingly reduced.

Land subsidence roughly can be predicted from tests of core material prior to production, but the only precise measure is obtained by measurement of surface altitude before and during production. The impact of subsidence may be negligible in isolated or undeveloped areas, but in a developed area, particularly where rivers and engineering structures such as canals require maintenance of a constant grade, the adverse impact could be very severe. Wells penetrating compacting sections commonly could be severely damaged by the compaction.

One means of alleviating the potential subsidence problem, and at the same time disposing of unwanted waste water, is through pressure maintenance by reinjection of such wastes through wells completed in the producing zone or in another reservoir. However, this can lead to the potential adverse impact of increasing seismicity. As noted earlier, experience in several parts of the world has shown that pronounced changes in fluid pressure in confined systems can lead to instability and subsequent earthquakes. Indeed, fluid injection into fault systems has been proposed as a means of triggering earthquakes and thus relieving accumulated strain before a major earthquake occurs. The relationship of fluid-pressure changes to earthquakes is not well known and research in this field has barely begun. Impacts could be beneficial or adverse.

While geothermal development will impose some unavoidable adverse environmental impacts, it appears to have the potential of being less environmentally damaging than other power generation systems using coal, oil, or nuclear energy sources. To the extent that there are net reductions in air, water, or land adverse impacts, such differences represent a positive benefit from use of geothermal resources.

E. THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

1. General

The leasing of lands for geothermal resource development involves the commitment of a portion of the geothermal heat, water, and related land areas and resources of the sites involved. The extent and nature of these commitments and an assessment of their potential environmental impacts have been described in detail in the preceding sections. It is particularly significant to recognize that the geothermal heat is a wasting resource that otherwise would be dissipated over time from the surface of the earth to the atmosphere with little or no identifiable benefit. By contrast, development of this resource in an environmentally acceptable manner can have substantial benefit by affording a relatively clean power generation energy source.

The exploration and testing phases of geothermal leasing are designed to determine the nature and extent of geothermal resources. Generally the active portion of this phase is of short duration, sometimes extending only over a period of days, months or, at most, a few years. It may be intensive and continuous for short periods or periodic over several years. Where such exploration proves unsuccessful there would not be subsequent use of the lands for development and production of geothermal resources. Under such conditions, leases would terminate at the end of the 10-year primary term. However, in many instances such leases would be relinquished by the lessee at an earlier date to avoid additional lease payment costs. Exploration and lease provisions require that lands disturbed by unsuccessful exploration will have to be restored as nearly as possible to their original condition upon termination of these activities. Such restoration would include measures such as grading, installing proper drainage, soil stabilization, revegetation, removal of all equipment and supplies, proper removal or disposal of all wastes, filling in of holding ponds, etc. Except for scars from leveling of drilling sites, roads or other major earth movement, the areas should return to natural conditions in a short time. Changes in vegetative cover may result, depending upon whether native or non-native plants are used. In some instances, such changes could be beneficial for wildlife. In a few years, native vegetation may retake the area in some biomes. In the desert biome, aesthetic and vegetative impacts may last over a long period of years due to slow natural recovery factors.

Where exploration discloses the existence of economically attractive geothermal resources, the development and production of such resources for electric power generation, and possibly water and mineral by-products, could be expected to occur. Timing of such development will depend upon electric power markets, power transmission systems, construction schedules, etc. Once production begins, the geothermal resource would be withdrawn at a rate greater than the natural replenishment rate. Over a period of years (perhaps 20 to 50 years, depending upon the nature of the resource province) production capacity would be depleted to the point where further

operation would not be economically feasible. When the reservoir is no longer capable of sustaining the geothermal operation, the leases would terminate, the facilities would be dismantled, and the land would be restored, insofar as practicable, to its original condition. Most of the area involved in the operation would have become well stabilized except for the actual areas used for the generation facilities, roads, or other structures or facilities. Removal of improvements would result in some disturbance, particularly in well and steam pipeline areas, but such disturbance would be of a temporary nature and subject to appropriate restoration. Unless the land areas occupied by production facilities were to be used for some subsequent and nonrelated purpose, they would be properly graded, drained, stabilized, and revegetated so that they would again become a part of the natural environment. Relatively large areas of level land would remain, such as the power generator site. Cuts and fills for roads, steam pipeline routes, etc. likewise would remain visible. However, the combination of restoration and natural vegetative recovery will, over time, result in a near natural setting with only contour change as evidence of prior uses. The lands would return to their former productivity or they would be available for other appropriate uses.

2. The Resource

By developing geothermal resource potentials, a previously unused natural resource would be tapped to help meet the Nation's growing energy needs, especially the need for electric power. While the benefit primarily would be in the West, actual benefits would be national as well since it would preclude the need for providing alternative sources of power, e.g., oil, coal, nuclear resources, etc. from other regions or even foreign countries. Such resources then could be used as necessary to meet the needs of other areas.

The generation of power would be the principal use of geothermal resources. However, there also is a good possibility that by-products of water or minerals might be possible, at least at some locations. In terms of total energy requirements, the contribution of geothermal resources may be relatively small but it can be important, particularly on a local or regional basis. In most instances the relatively small generation capacity for each site will serve to supplement other forms of electrical energy generation. As such, it will replace an equivalent amount of electricity that otherwise would have had to have been produced from an alternative source, probably steam-electric systems, using natural gas, oil, coal, or nuclear fuels. The use of such fuels, particularly oil, coal, and nuclear, generally imposes greater adverse environmental effects than will result from use of geothermal resources. Such problems involve air pollution, water pollution, radioactive exposure, thermal waste discharges to water or air, land disturbance from mining, transportation hazards, etc.

Geothermal resources may contribute to the production of chemicals from the brines and fresh water through desalinization. In many cases the geothermal resources may not be of sufficient temperature to be useful for

electric power production but will be useful for space heating or industrial processing.

While depletion of some of the heat within the geothermal reservoir would occur over the period of operations, no permanent adverse effect is anticipated. Over time, perhaps a hundred or more years, natural heat transfer within the earth might even return the heat content to nearly the same intensity as existed before utilization. At some time in the relatively distant future it might be possible for such areas to again be used for similar productivity. Any use of by-product minerals probably would represent mineral recovery that otherwise would never have occurred. Such use would preclude the need to obtain a like amount of such materials from other sources. Where waste waters are reinjected, the associated mineral values would be returned to the earth.

3. Water

The consumptive use of water resources, primarily geothermal fluids, in the power generation or mineral by-product process would constitute a depletion of the gross water resources of the area. To the extent that geothermal fluids are withdrawn from the subsurface reservoir and not replaced by reinjection or natural recharge, the water so consumed would represent depletion of water in storage. However, in most instances, due to high mineral content, this would be water that otherwise probably would not be used. If subsidence should occur, the water storage capacity of the geothermal reservoir would be permanently reduced but since such waters probably could not be used for other purposes within the foreseeable future, the reduced storage impact may not be adverse in terms of future water productivity.

Geothermal fluids also may be of sufficient purity to be used directly for irrigation or other purposes after the fluid has been cooled. This could provide a source of fresh water during the period of power operation and it is possible that the wells could continue to be used even after power production has ended. In some areas, such as Imperial Valley, the geothermal fluids are expected to be concentrated brine which would not be suitable for any other purpose. In such situations, the wells would be sealed upon termination of power generation. The use of such water should not affect water resources available for beneficial use.

Under the proposed controls for waste disposal, degradation of surface and fresh ground waters is not expected to be significant, expecially in a long-term sense. Mishaps or accidents may have short-term impacts that, depending upon the volume and nature of discharge involved, could be serious, particularly on aquatic resources. However, corrective measures such as dilution, diversion of waste waters from streams, capturing water in impoundments, etc should provide adequate measures against serious or long-term impacts.

4. Land

Land uses during the period of production operations would be changed to industrial operations from fish and wildlife habitat, recreation, grazing, forests, agriculture, etc. However, many such uses could continue on a reduced compatible basis. Wells, pipelines, power plants, by-product facilities, and power transmission facilities would dominate the local area. Public access in the vicinity of such facilities would have to be restricted to protect the public and the facilities. Development and production of geothermal resources generally are not expected to have any lasting or inhibiting effects on the use of the land after geothermal operations have been concluded and the facilities have been removed.

Should geothermal production result in land subsidence, which is an irreversible process, the subsidence would constitute a long-term effect on the land resources. Such subsidence would not significantly affect use of the land in most areas, except where changes in slope and elevation could affect waterways and engineering works. Such changes would represent a serious short-term impact on engineering structures but, in the long term, could be accommodated by engineering modifications, mainly realignment and reconstruction of the affected structures or works. Impact on waterways could be irreversible.

5. Fish and Wildlife

Geothermal resource development could result in certain localized and regional adverse impacts on fish and wildlife and their habitat. There could be a loss of wildlife habitat in the immediate vicinity of installations, minor loss of birds from collision with and/or electricution on electric distribution lines, and potential danger to fish and other aquatic life from toxic fluids in the water. In addition, restrictions of public access would reduce hunting and related recreational opportunities in the vicinity of installations. A change in the natural setting of lands could result in long-range effects on wildlife by rendering some lands less desirable for wildlife habitat purposes. Wildlife values probably would reestablish themselves as soon as the operations are terminated. In some instances they may even benefit from this use.

6. Economic and Social

Geothermal development requires substantial investment in drilling wells and construction of roads, pipelines, power and by-product plants, and transmission lines. Such investments result in an increased tax base for the area of development. However, the labor-intensive phase is short-term, occurring primarily during field development, and would not result in significant changes in population distribution. The economic benefits probably would be more in the nature of transfer benefits as a corresponding power generation capacity would have to be developed elsewhere if the geothermal resources were not developed.

Table III-11 reflects estimated costs of electricity from variously fueled plants. Generally the costs for a hot water geothermal plant are comparable to hydroelectric, nuclear, and oil fired plants. Dry steam plants would be much less costly, but few dry steam sources are expected to be found. Gas fired power plants have a cost advantage but, due to the increasing scarcity of natural gas, continued use of remaining supplies represents a waste of this cleanest of energy resources. Coal fired plants appear to have a cost advantage provided increasingly stringent air quality standards can be met without significant increases in coal production or utilization processes.

Geothermal resources can be economically competitive where such resources can be developed near existing power systems or where additional transmission costs are nominal. Since the generation capacity at each site may be small, substantial investments in power transmission systems could cause such development to be uneconomic.

There could be some aesthetic or social impacts in terms of increased noise levels, odors, additional traffic, etc. even though all of the environmental stipulations of the permits are met. These would be minor but objectionable in terms of pre-operational conditions. Since such operations could continue for a period of 25 to 50 years, they would exist during most of the lifetime of local residents or users of these areas.

Table III-11. Estimated Cost of Electricity from Variously Fueled Plants

Item	Gas-fired * 1/	Coal-fired * 2/	Hydro-electric	Nuclear**	Geothermal* (Hot water)	Oil-fired * 1/
Unit investment cost of plant $/KW 3/	105	225	390	300	4/ 290	115
Annual fixed charge, percent of investment 5/	17	17	17	17	4/	17
Kilowatt-hours generated per year per KW capacity 6/	7,000	7,000	7,000	7,000	7,000	7,000
Heat rate 7/	10,000	9,500	--	10,600	15,700	10,500
Cost of fuels, cents/million Btu	34.8	20.3	--	17.5	8/ 37.6	61.5
Cost of electricity, mills/kwh						
Plant investment	2.6	5.5	9.5	7.3	2.3	2.8
Operation & maintenance	0.6	0.8	0.1	0.4	1.5	0.7
Fuel	3.5	1.9	--	1.9	5.9	6.5
Total	6.7	8.2	9.6	9.6	9/ 9.7	10.0

1/ Outdoor type plant.
2/ Indoor type plant. All figures valid only for western states.
3/ Includes land, structures, boilers, turbine generators, electrical equipment, miscellaneous plant equipment. Excludes switchyard.
4/ See following page for explanation of investment costs and annual fixed charges.
5/ Includes cost of money, depreciation, interim replacements, insurance, and taxes.
6/ The 80 percent operating factor used here is applicable only to base load plants. Hydro is seldom a base load plant.
7/ Varying heat rates representative of power plants under consideration when base loaded.
8/ Cost of fuel based on capital and operating costs of steam-winning system.
9/ Comparative cost for dry steam approximately 5.3 mills.

* Derived from 17th steam station cost survey, Electrical World, Vol. 176, Nov. 1, 1971.
** Derived from Hottel and Howard, New Energy Technology; article by Benedict, "Electric Power for Nuclear Fusion," Proceedings of National Academy of Science 68.

Table III-11 (continued)

Geothermal Plant Investment and Annual Fixed Charges 1/

Item	Unit investment costs	
	10-year life	30-year life
Production well system	$ 48	$ 25
Injection well system	75	32
Make-up water system	7	8
Subtotal, steam winning system	$130	$ 65
Generating plant 2/	0	95
Total	$130	$160
Annual fixed charges, percent of investment 3/	23	17

1/ Steam-winning costs based on Geothermal Resources Investigation, January 1972, by Bureau of Reclamation. Costs escalated to reflect inflationary trends in construction industry.

2/ Includes structures, turbine generators, electrical equipment, miscellaneous. Excludes land, steam-winning system, switchyard.

3/ Includes cost of money, depreciation, interim replacement, insurance and taxes.

F. ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION SHOULD IT BE IMPLEMENTED

This topic is generally covered in the preceding section. The principal commitment of resources would be the depletion of thermal energy and water from the geothermal reservoir. Both of these resources are renewable but not within the life span of a specific project. Once they were depleted to the point where economic production could not continue, production would stop, facilities would be removed, and the area would be restored to as nearly a natural state as is practicable. There is no foreseeable alternative use of the stored energy other than possible space heating. The associated water produced by the operation could be of significant value if it were of sufficiently good quality, either naturally or by desalination, to be used for other purposes.

Compaction and resulting land subsidence that may result from the removal of geothermal fluids could have irreparable consequences. An equivalent amount of water storage would be lost. In developed areas, substantial adjustments might be required to compensate for such subsidence (agricultural lands, irrigation canals, highway drainage, etc.). If seismic action should result from fluid withdrawal or reinjection, there could be considerable damage, depending upon the severity of such action.

Some onsite or related ecological features such as plant life, wildlife, and aesthetics could be altered. Cuts and fills for plant sites, production wells, roads, etc. could leave landscape scars. In some instances, roads might be retained as permanent access routes to facilitate other land uses. The extent of such alterations will depend upon the individual site and the nature of development.

Dedication of the land surface to industrial uses generally will result in land areas being used for wells, associated surface facilities, powerplants, roads, and transmission lines. While not of a permanent nature, such uses will represent a commitment for a period of 25 to 50 years. This is a relatively long period in terms of human lifetimes and related alternative uses of these lands and their other resources. Human energy, money, and construction materials are other resources irretrievably committed in the development of geothermal steam. However, to the extent that these resources represent a commitment to increased power generating capacity to meet regional or national needs, their consumption would be necessary regardless of the technology utilized in the generating process.

CHAPTER IV

ALTERNATIVES TO THE PROPOSED ACTIONS

A. INTRODUCTION

The proposed actions are: (1) the promulgation of leasing, operating, and unit plan regulations pursuant to which the geothermal leasing program would be administered, and (2) the leasing of federally owned geothermal resources in three specific areas in California: (a) Clear Lake Geysers, (b) Mono Lake-Long Valley, and (c) Imperial Valley.

The proposed geothermal leasing regulations and program provide for private sector exploration, development, and production of Federal land geothermal resources. The Federal role primarily involves the administration of exploration, leasing, development, and production activities consistent with the Department of the Interior's mineral management objectives of: orderly and timely resource development, protection of the environment, and receipt of fair market value for leased mineral resources. Under Secretarial Order No. 2948, dated October 6, 1972, these objectives are set forth as follows:

"1(a) Orderly and Timely Resource Development includes the Department's responsibilities to:

"(1) Foster, promote, and encourage the exploration for and the production of the mineral deposits from the leasable lands; promote competition;

"(2) Encourage the active development of the mineral deposits in the leasable lands in a manner compatible with the use of the same lands for other purposes; assure that mineral developers receive the acreage necessary for economic plant investment, development, and production;

"(3) Encourage the maximum ultimate recovery of the mineral deposit; prevent waste; promote the conservation of the mineral resources;

"(4) Assure adequate minimum production and diligent development requirements for mineral deposits.

"(b) Protection of the Environment includes the Department's responsibilities to:

"(1) Assure that mineral exploration and production be conducted with the maximum protection of the environment;

"(2) Assure the rehabilitation of disturbed lands;

"(3) Assure that precautions are taken to protect public health and safety; and

"(4) Assure full compliance with the spirit and objectives of the National Environmental Policy Act of 1969, other Federal environmental legislation, and supporting Executive Orders and regulations.

"(c) Receipt of Fair Market Value for Leased Mineral Resources includes the Department's responsibilities to assure the public a fair market value return for the use of public lands and the disposition of its mineral resources."

The primary use of geothermal resources to date is for the generation of electricity. Under existing technology, geothermal steam is expanded into a low-pressure turbine which drives a conventional electric generator. In some areas the geothermal reservoir produces natural dry steam that can be brought to the surface and introduced directly into the turbine. In other areas geothermal fluids, under pressure and heated beyond the boiling point, are brought to the surface. A portion of this fluid flashes into steam which is used to drive the generator turbine. Such geothermal fluids could be kept under pressure and passed in liquid form through a heat exchanger to heat a secondary lower boiling point fluid to produce a vapor for use in driving the generator turbine. Considerable interest has been shown in the possibility of introducing water or other fluids into hot subsurface strata which otherwise would not naturally produce steam of high temperature fluids. The heated product then could be used in the same manner as natural steam or high temperature fluids.

The technology for utilizing hot dry steam for the generation of electric power is well developed and in operation. The flashing of very hot water into steam at the surface also is being used, but only a portion of the heat value of the fluid is utilized. Technology for passing hot water through a heat exchanger has been developed and utilized on a semi-commercial scale and larger systems are being planned. Little is known as to the feasibility of introducing fluids into heated subsurface formations for the production of steam of high temperature fluids.

Geothermal resources also can be used directly in lieu of electrical or other energy sources in the heating and air conditioning of buildings, in the heating of hot houses and soil for agricultural purposes, and in product processing. Geothermal resources also have potential use in refrigeration and freeze drying. Some geothermal fluids contain potentially valuable mineral by-products. Production of fresh water by desalination of geothermal fluids also may be possible.

Geothermal resources are a heat energy source similar in end use to fossil fuels. However, there is a major difference in that fossil fuels must be burned or processed in some way to convert their energy potential to heat. By contrast, the geothermal resource energy is in usable form at the site of production.

Alternatives to geothermal development primarily involve processes which would produce an equivalent amount of electrical power. Mineral and

water production probably would be by-products of electric power development. In evaluating alternatives, the entire fuel cycle must be considered. This includes the impacts of mining, processing, transportation, power production, and the disposal of wastes. A significant factor relative to geothermal resources is that environmental impacts generally are restricted to the production site whereas much of the environmental impact of other methods of power generation takes place at several locations often far removed from the actual point of power generation (mining and processing of coal and uranium, oil and gas production, imports from foreign countries, waste disposal sites, etc.). Support operations such as these are not required for geothermal production. For this reason, the environmental effects are site dependent in origin and thereby are subject to specific environmental control actions and monitoring to assure environmental acceptability. However, certain undesirable effects such as subsidence, increased seismic activity, odors, etc. can impose environmental problems in areas proximate to the production site.

The overall environmental effects of geothermal resource utilization appear to be potentially less adverse than those associated with comparable operations utilizing fossil or nuclear energy sources. However, site sensitive environmental evaluations will have to be made to identify those situations in which geothermal resource development might result in unacceptable environmental impacts or where alternate sources of an equivalent amount of energy would be economically and environmentally more advantageous.

B. DISCUSSION OF ALTERNATIVES

The development of federally owned geothermal resources could be accomplished using various exploration, timing, regulatory and leasing procedures which could have different degrees of environmental impacts. Since the primary use of geothermal resources probably will be for electric power generation and heating, alternative energy sources must be considered in terms of their comparable use and relative environmental impacts. Major alternatives to the proposed actions are discussed in the following sections. Specific alternatives relative to the three areas proposed for leasing are included in the individual area statements in Volume II of this statement.

The following alternatives are discussed in this chapter:

1. Promulgation of leasing and operating regulations

    a. Alternative timing of actions
    b. Alternative regulation environmental provisions

2. Alternatives for leasing of geothermal resources

   a. Open all but the excepted federally owned resources to leasing
   b. Lease only those lands classfied as KGRAs and PGRAs
   c. Lease only those lands classified as KGRAs
   d. Lease only in connection with adjacent private land development
   e. Lease areas of greatest potential relative to electrical energy needs
   f. Prototype leasing
   g. Lease only to honor "Grandfather" rights
   h. Prospecting permit leasing program
   i. Preleasing nomination system
   j. Maximize competitive leasing for nonclassified land
   k. Noncompetitive leasing for all areas outside of KGRAs and PGRAs

3. Alternatives for exploration and development

   a. Federal exploration and development
   b. Joint or coordinated Federal and private sector exploration and development

4. Alternative sources of electrical energy

   a. Coal
   b. Oil
   c. Oil shale and tar sands
   d. Natural gas
   e. Nuclear energy
   f. Hydroelectric energy
   g. Other energy sources
   h. Conservation of energy

1. <u>Promulgation of Leasing and Operating Regulations</u>

The Geothermal Steam Act authorizes the Secretary of the Interior to make disposition of geothermal steam and associated geothermal resources. Section 15 of the Act provides that leases may be issued only under such terms and conditions as the Secretary may prescribe to ensure adequate utilization of the lands for the purposes for which they were withdrawn or acquired. Accordingly, regulations such as those proposed must be issued if Federal resources are to be leased. However, the timing of issuance and the regulatory approaches could be treated in alternative manners.

a. Alternative timing of actions

(1) Do not initiate a program for the development of federally owned geothermal resources

As indicated in Chapter II, Section B, projected development of geothermal power on both public and privately owned lands may represent nearly 2 percent of total U.S. energy consumption by the year 2000. Since most of the potential geothermal production areas are in the public lands of the 11 western States and Alaska, most of this potential development is contingent upon the leasing of federally owned geothermal resources. Geothermal development in other countries and on the private lands of the U.S. could be expected to continue. These programs could be monitored for significant discoveries and technological developments as a basis for future reconsideration of the need for the development of federally owned resources.

The Administration's program, as emphasized in the President's Energy Message of June 4, 1971, is intended to provide for the utilization of geothermal resources under environmentally safe conditions and sound resource management practices. The President, in his Energy Message of April 18, 1973, again outlined the potential for geothermal energy. It is expected that the leasing of geothermal resources on public lands will stimulate development of this energy source. The decision to proceed with a leasing program would be contingent upon leases incorporating environmentally safe operating and development practices which assure that development and production will be accomplished in an environmentally acceptable manner. Such practices and their anticipated environmental consequences are set forth in detail in this statement.

A decision not to lease federally owned geothermal resources would result in nondevelopment of this energy potential at a time when the Nation is facing a vitally important energy challenge. There is a rapidly growing gap between the demand for energy and the capacity and the resources to meet future needs. Development of geothermal resource potentials could help to meet part of this need, particularly for local areas which, in turn, could contribute to the solving of regional or national problems. If geothermal resources are not developed, the environmental disturbances as set forth in this impact statement would not occur. However, as indicated in the discussion of electrical energy alternatives, the development of an equivalent amount of energy from alternative sources could have greater adverse impacts than are expected to result from development of federally owned geothermal resources.

(2) Delay implementation of a leasing program pending additional environmental evaluation

The potential environmental impacts associated with exploration, test drilling, production testing, field development, power plant and powerline

construction and full-scale operations, and area restoration after production ends are discussed in detail in Chapter III, Section B of this Volume. Part C of that chapter presents the mitigating measures to be taken to assure that geothermal development is accomplished in an environmentally safe manner and outlines the areas in which major environmental problems exist. Potential impacts and mitigating measures are further discussed as they pertain to the three areas proposed for leasing in the environmental evaluations included in Volume II of this impact statement.

Delaying the implementation of a leasing program could allow time for further environmental evaluation. Such evaluation might not be of much value until potential development areas and individual lease sites have been better defined, delineated, and tested as many of the impacts are highly site-sensitive. However, as a result of geothermal development on private lands, new technologies and systems may be developed to comply with State and local government environmental requirements. Experience gained from such operations could be used to improve the environmental evaluations for potential Federal land leases.

A delay of several years probably would not have a significant impact on the national or regional energy situation but it could have local impacts, particularly where power must be imported from other areas. If geothermal development for public and private lands should be in the projected range of 4,000 to 19,000 Mw by 1985 (as indicated in Chapter II, Section B), from two to ten steam fossil fuel or nuclear generation plants could meet this need. Since individual geothermal installations will be small (perhaps up to 100 Mw), fossil fuel or nuclear plants still probably would be built but perhaps at a slower rate due to local needs being met, to some extent, from geothermal sources. Environmental impacts will result from either power source so the comparison primarily involves timing and the total systems associated with producing equivalent amounts of electrical energy.

Delaying Federal leasing could result in discouraging private investment in private land development and in research. If this should happen, the potential advantage of learning from such experience would be lost and the solving of potential environmental problems would be delayed or would not occur.

Private land geothermal development may take place on lands that are comparable or different from Federal lands in terms of surface resource and environmental values. However, problems such as compliance with water and air quality standards generally will be comparable. Since the proposed regulations require appropriate compliance with such standards, little environmental value probably would be derived from the delay of a leasing program. Some private land operations may progress to the point of full compliance capability before Federal areas are brought into production, and such systems could be used for production on Federal leases. However, there may be problems associated with the steam or geothermal fluids from individual reservoirs which can be

treated only on a site-by-site basis. Such problems would have to be solved at the time of development before operations would be permitted. Generally, the delay of a leasing program would have little environmental advantage for such problems cannot be evaluated in advance of test drilling and testing of geothermal steam or fluids at each site.

While there is still much to be learned about other potential environmental impacts, particularly surface values, the impacts associated with exploration, testing, road construction, etc. are not new. Similar activities occur in connection with oil and gas, coal, mineral mining, timber harvest, etc. The land management agencies know how to evaluate such impacts and have considerable experience in taking the necessary mitigating and corrective measures. Generally, most of the same types of environmental protection actions would be applicable to exploration, development, and construction associated with geothermal development.

Geothermal development probably will begin relatively slowly. Initial developments probably will be in the areas of greatest economic production potential which are in proximity to areas where the power can be utilized with a minimum of additional transmission facilities. The experience gained from actual operations should provide greater environmental benefits in terms of future environmental evaluations than would derive from delaying leasing pending further environmental study, much of which would be contingent upon actual operation within the various environmental settings involved. The proposed regulations provide for further environmental evaluations as development progresses to ascertain what additional actions are required to assure that production can be accomplished in an environmentally acceptable manner.

(3) Delay implementation of leasing program until development of new or improved technologies for the use of geothermal resources

The utilization of geothermal resources is relatively new in the United States. More needs to be known about the nature of geothermal reservoirs and how to develop and utilize their resource potential in the most effective manner. The amount, intensity, and timing of research and technology development will have an important bearing on the overall rate of development of geothermal resources. In some instances, assessment of technologic and economic feasibility may have to await new systems for development, testing, and production.

The various geothermal systems are described in Chapter II, Section B. These include:

Vapor dominated systems (such as The Geysers)
Hot water systems
Geopressure reservoir systems
Hot dry rock systems

The only presently producing system in the United States is the vapor dominated system at The Geysers in California. Vapor systems are thought to be relatively rare so they are not expected to represent a major portion of the geothermal energy potential. Hot water systems are being utilized in New Zealand, Japan, and Mexico. The technology for energy production from steam and hot water systems has been proven. There could be technologic and environmental problems associated with the development of other geothermal systems before efficient and economic utilization may be possible. Some of these problems relate to entire systems while others will be peculiar to individual sites.

Technological and resource information considerations also were discussed in Chapter II, Section B. Specific examples of resource investigation and technologic research that could result in new or improved systems for location, exploration, development, and production systems and related environmental protection factors include:

(a) <u>Geologic investigations</u>

Develop new equipment, systems, and techniques for identifying, delineating, and evaluating geothermal areas.

Establish more adequate and reliable knowledge of the physical characteristics, nature, and dynamics of potential geothermal systems as a basis for development and utilization in an efficient and environmentally safe manner.

Determine more precisely the potential environmental effects of geothermal production as they relate to fault zones, earthquakes, subsidence, ground water, and other subsurface factors.

(b) <u>Environmental monitoring</u>

Knowledge is limited relative to the potential environmental impacts and effective mitigating measures associated with fluid and heat removal from the ground. Improved monitoring systems could be developed which might assure earlier detection of potential adverse impacts to facilitate the taking of necessary corrective measures to minimize adverse impacts. This could include factors such as: induced tectonic changes, contamination of ground and surface waters by mineralized effluents, and the effects of brine reinjection on regional groundwater systems.

Development of monitoring systems and capabilities could precede geothermal development but their testing and utilization probably would have to be done as a part of actual operations under a wide variety of conditions that may exist relative to different geologic situations and individual development areas.

(c) <u>Engineering research</u>

New and improved technologies may be needed for extraction and utilization of geothermal resources from the various geothermal systems and for

individual reservoirs within each type of system. There may be considerable potential for improving the use efficiency of geothermal heat. There also are potentials for the production of fresh water and minerals. Examples of engineering research areas include:

— Basically, the techniques used for geothermal resource development and extraction are modified versions of oil field technologies. While such systems may work for vapor dominated and hot water systems, there could be considerable opportunity for significant improvements in drilling techniques, reservoir development, recovery systems, and for environmental factors such as blowout prevention and control, fluid reinjection systems and procedures, monitoring, etc.

— Present geothermal electrical energy conversion systems use dry steam or that portion of the geothermal fluids that flash to steam. Much of the heat, particularly in hot fluids, is not utilized. Increased thermal conversion or utilization efficiencies would improve resource conservation and increase the usable energy obtained from the same amount of withdrawn geothermal steam or liquids with little or no increase in environmental impacts. It would reduce the need to obtain an equivalent amount of energy from other sources with a corresponding decrease in the environmental impacts associated with such an energy source.

— The minimum water temperature which now can be used for power generation by steam turbines is about 180° C. The potential for use of geothermal resources could be greatly increased if economically feasible systems could be developed to use lower temperature resources. An example of such a system could be a low boiling point fluid such as freon in a closed circuit heated by geothermal fluids in heat exchangers. Such closed circuit systems could eliminate, or greatly reduce, many of the environmental problems that may be associated with open systems. However, they could pose cooling problems involving potential thermal pollution.

— Many geothermal areas with high thermal gradients may have little or no mobile fluids. Systems might be developed that would utilize this heat source. Such systems might include water injection and withdrawal with use comparable to hot water systems or closed low boiling point fluid systems.

— There may be potential for resource, environmental, and economic advantages to the salvage of minerals and gases from geothermal fluids. Such by-products could serve to meet a portion of the demand for such minerals, thereby avoiding the need for development of domestic sources or import of equivalent amounts. Since the fluids and gases already are being handled and must be disposed of, salvage could enhance economic development potentials and fuller utilization of resources with little or no additional environmental impact. The potential adverse impacts associated with producing such minerals from other sources would be avoided. Geothermal waste disposal problems might be reduced since a portion of the wastes would be eliminated as a result of mineral salvage.

— Waste disposal methods may be developed which could minimize potential adverse hydrologic, chemical, or other impacts and to mitigate other potential problems such as subsidence and seismic activity.

— Desalination of geothermal fluids could provide a source of fresh water. Since these fluids already are at high temperature, the energy requirements for desalination processes would be greatly reduced. However, that portion of the electrical energy production used for desalination processes would not be available for the meeting of other energy needs of the area. If economic dual purpose processes could be developed, they might result in the most efficient use of the total geothermal resource, particularly in water-short areas such as the Lower Colorado River Basin.

(d) Industrial uses

Many industrial processes require large amounts of hot water and heat. Such heat requirements generally are met through the use of fossil fuels, either directly or in the form of electrical energy. The use of geothermal fluids for such heat could substitute for fossil fuel sources if efficient utilization systems could be developed.

(e) Agricultural uses

Geothermal fluids might be used for increasing agricultural production in colder climates. Iceland grows flowers and vegetables in glass houses heated by natural hot water. The USSR has been experimenting with soil heating systems. Research would be required to determine the best conditions for use of various temperature geothermal waters and the types of agricultural production possible.

(f) Space heating

In Iceland, about 40 percent of the population lives in homes heated by geothermal energy. This use is estimated to preclude the need to import 210,000 tons of fuel oil per year (Einarsson, 1970). Similar uses occur in Japan. Water temperatures for such uses range from 40° C to 70° C. In the United States, several small areas use geothermal resource for space heating. Klamath Falls, Oregon, operates about 400 wells for space heating using heat exchange systems. Development of geothermal resources, and improved heat exchange and delivery systems, could provide a clean heat source for homes or even entire communities. This might eliminate the need for other heat sources whose environmental impacts may be greater than those associated with the use of geothermal resources.

Various research activities such as these could be accomplished by the Federal Government, the private sector, or by various mixes of Government/private effort. Some of the research could be accomplished before the development of geothermal resources but much of it would have to be done in connection with actual development and production operations,

particularly where there are significant factors related to individual sites. These could be either experimental pilot plants or commercial operations. Since resource development and utilization on both private and public lands will be by the private sector, related research must be closely associated with development and investment plans. Development probably will begin slowly on those sites offering the best economic potential using existing technologies. It can be expected that new technologies will be developed currently as needed by industry to solve problems on a site-by-site basis to provide the systems required for geothermal production from each site, other areas, and ultimately from other geothermal systems.

Since much of the geothermal resource potential is on Federal lands, delaying the leasing of such lands could have a corresponding delaying effect on the accomplishment of research and development other than that which would be done in connection with private land operations. Since all geothermal operations on Federal lands must be conducted in an environmentally acceptable manner, there could be a significant stimulant to research since potential operators know they will have to develop and operate systems that will meet leasing requirements. The experience gained from initial leasing could provide a better basis and incentive for such research, particularly as it pertains to environmental and use efficiency factors.

Research related to by-product production of minerals or the production of fresh water may be of nominal interest to the power industry at this time. However, when the necessary research is done, new technologies could be applied if such production was economically feasible. In most instances, the addition of by-product processes could occur after power production begins. In many instances, the potential could not be developed until after production testing of wells as processes would have to be designed for individual sites.

It is highly probable that the most effective and timely research could result in connection with actual exploration, development, and operations on Federal lands because of the broad range of development opportunities and the related strict environmental requirements. As previously indicated, delaying the leasing program pending the development of new or improved technologies probably would result in a corresponding delay in the development of geothermal resource potentials with environmental consequences similar to those described for other actions involving postponement of leasing.

b. <u>Alternative regulation environmental provisions</u>

In the formulation of the environmental provisions of the proposed regulations various approaches were possible such as:

(1) Include explicit environmental standards, provisions, and requirements for each section or subsection having significant environmental considerations.

(2) Confine regulations to general leasing provisions with all major environmental stipulations and conditions being provided for in geothermal leases, permits, and related Geothermal Resource Operating Orders.

(3) Include explicit environmental policies and concepts with mandatory compliance with Federal and State environmental protection standards subject to more stringent standards as appropriate on an individual lease site-sensitive basis through lease stipulations, Geothermal Operating Orders, or whatever orders as are appropriate to assure adequate environmental protection.

There will be great variation in the potential environmental impacts associated with the development of geothermal resources under the wide range of resource systems and environmental settings involved. Development activities are described in Chapter II, Section C. General descriptions of the wide range of environmental settings are presented in Chapter II, Section D, and differences are clearly evident in the environmental evaluations for the three proposed lease areas as described in Volume II of this impact statement. The nature of potential environmental impacts is discussed in detail in Chapter III, Section B, and in each of the three proposed lease area statements. Mitigating measures are covered in Chapter III, Section C, and in the three area statements.

(1) <u>Explicit environmental standards, provisions, and requirements</u>

Each geothermal system, each reservoir within such systems, and each individual development area may present both similar and entirely different environmental hazards and problems. Each State and local government area may have wide variations in water, air, and other environmental standards, regulations, and requirements. What may be environmentally acceptable under one situation might be unacceptable elsewhere. Environmental requirements and technologies for meeting or even exceeding minimum requirements are expected to change. Geothermal knowledge now is limited since there is only one operational system in the United States and it utilizes a vapor dominated steam resource. As other areas and geothermal systems are explored and developed, there will be a rapid increase in knowledge and experience. There also should be great progress in the development of systems that can provide for geothermal resource utilization in an environmentally safe manner.

Such factors are not conducive to development of explicit environmental standards, provisions, or requirements in general leasing and operating regulations. Each area and lease site must be individually evaluated and appropriate specific provisions must be included in each lease and related permits, Geothermal Resource Operating Orders or other orders. In many situations, general orders would be too lenient or would not provide for many local environmental factors. There could be conflicts, voids, misunderstandings, or other problems where there were differences between environmental provisions of the regulations and environmental provisions associated with individual leases.

(2) <u>Confine regulations to general leasing provisions</u>

Leasing regulations could be limited to procedural, definitional, and legal factors such as the delineation of available lands, qualification for lessees, leasing terms, etc. without the inclusion of general or specific environmental protection requirements. Operations still would be subject to applicable Federal and State laws for water and air quality or other environmental factors. Environmental protection stipulations and requirements would be included in individual leases, permits, and operating orders by the officials responsible for their development, approval, and administration. Such controls could be based upon separate guidance, instructions, or administrative orders issued by the Secretary and/or the responsible agency head.

Under this alternative environmental protection requirements could be greater than, less than, or equal to the provisions as included in the proposed regulations. The Secretary could require the same degree of compliance as will result under these regulations. However, there are those who would feel that failure to include adequate environmental protection stipulations in the regulations would indicate less of a commitment to assuring that all geothermal development will be accomplished in an environmentally acceptable manner in all phases of geothermal development from prelease considerations through all operational stages to final removal of facilities and restoration of disturbed areas.

There could be wider variation in the interpretation of departmental policies and in the formulation and implementation of environmental protection stipulations, actions, and controls. While it probably would be possible to achieve environmentally acceptable operations, there could be greater possibility of oversights, challenges, misunderstandings, environmental compromises, etc. than would result from regulations which clearly spell out the environmental commitments, policies and concepts, and operational procedures subject to appropriate State, local, and individual site considerations or requirements. There could be greater opportunity for adverse environmental impacts under this alternative even though operations still were conducted in a generally acceptable manner.

(3) <u>Include explicit environmental policies and concepts with mandatory compliance with Federal and State environmental protection standards</u>

The proposed regulations utilize this approach, which is repeated here to facilitate comparison. This begins with the preleasing procedures set forth in Section 3200.0-6 which provides for reports describing, to the extent known, resources contained within the general area and the potential effect of geothermal resources operation upon the resources of the area and its total environment. Prior to final selection of tracts for leasing, there could be a full evaluation of the potential effect of the leasing program on the total environment, fish and other aquatic resources, wildlife habitat and populations, aesthetics, recreation, and other resources in the entire area during exploratory, developmental, and operational phases. Section 3204.1 provides that a

lessee should comply with and would be bound by the general terms and conditions, the specific requirements contained in the lease stipulations, and any GRO orders issued pursuant to 30 CFR 270.11. Specific environmental protection measures are set forth in Section 3204.1 and compliance with Federal and State environmental protection regulations would be required. More stringent requirements would be imposed as necessary to assure that all geothermal operations would be conducted in an environmentally acceptable manner.

Under the operating regulations, the Supervisor would ensure that all operations within the area conform to the best practice and are conducted in such manner as to protect the deposits of the leased lands and to result in the maximum ultimate recovery of geothermal resources, with minimum waste, and are consistent with the principles of the use of the land for other purposes and of the protection of the environment. He would have full authority to take whatever actions as are necessary to regulate geothermal operations to accomplish such purposes. Such authorities and responsibilities are spelled out in detail in Part 270 of the proposed regulations.

Lease provisions, operating orders, and other orders as necessary would be formulated and issued within the environmental policies, concepts, procedures, responsibilities, and authorities set forth in the proposed regulations. Each geothermal lease area may have peculiar reservoir, surface, or other factors which would be individually considered to arrive at the appropriate development and production. The regulations as proposed provide policies and authorities to assure that geothermal resources on Federal lands would be developed to serve the public interest, including appropriate protection of environmental values. They are stringent enough to require protective actions and still afford the necessary flexibilities required to cope with specific environmental problems associated with any lease and its related operations.

2. Alternatives for Leasing of Geothermal Resources

Section 3 of the Geothermal Steam Act authorizes the Secretary of the Interior to issue leases for the development and utilization of geothermal steam and associated resources (1) in lands administered by him, including public, withdrawn, and acquired lands, (2) in any national forest or other lands administered by the Department of Agriculture through the Forest Service, including public, withdrawn, and acquired lands, and (3) in lands which have been conveyed by the United States subject to a reservation to the United States of the geothermal steam and associated geothermal resources therein.

Section 15(c) of the Act and Section 3201.1-6 of the proposed regulations provide that leases shall not be issued for lands which are (1) administered under the National Park System, (2) within a national recreation area, (c) in a fish hatchery administered by the Secretary, wildlife refuge, wildlife range, game range, wildlife management area or waterfowl production area, or for lands acquired or reserved for the protection and conservation of fish and wildlife which are threatened with extinction, or (4) tribally or individually owned Indian, Indian trust or restricted lands within or without the boundaries of Indian reservations.

Sections 17 and 24 provide that the Act shall be administered under the principles of multiple use of lands and resources and under regulations that provide for, among others, prevention of waste, development and conservation of the resources, protection of the public interest, maintenance by the lessee of an active development program, and protection of water and other environmental qualities.

Under the proposed geothermal leasing regulations, all federally owned lands, except those specifically excluded by the Geothermal Steam Act, departmental regulations, or other forms of withdrawal, would be available for leasing. This could involve as much as 550 million acres of federally owned lands (see Figure II-16a). However, a major portion of these lands does not appear to have geothermal potential.

The responsibility to classify lands as known valuable or valuable prospectively for geothermal steam and associated geothermal resources lies within the Geological Survey (GS). The GS has classified areas of the U.S. in three categories: known geothermal resource areas (KGRAs), prospective valuable geothermal resource areas (PGRAs), and unclassified lands.

KGRAs comprise 1.8 million acres of both private and Federal lands, of which approximately 1 million acres are federally owned. (Standards for such classification are found in G.S. Circular 647.) The Geothermal Steam Act requires that resources within KGRAs must be leased competitively.

PGRA lands comprise an estimated 95 million acres of which an estimated 54 million acres are Federal lands. PGRAs are areas within a geothermal resources province which contain an inferred geothermal reservoir but which have not been determined to be a known geothermal resources area. A PGRA is a specific and definable area which exhibits geologic structure and history indicating the possibility of a high geothermal gradient. In most prospective areas, data on geothermal gradients and conductive heat flow are scarce. Adequate temperature-depth data exist only in sedimentary basins that have been extensively explored for oil and gas. Most of these basins are characterized by nearly "normal" geothermal gradients rather than the abnormally high rates needed for development of geothermal energy (see G.S. Circular 647).

The KGRAs and PGRAs are concentrated in California, Oregon, Washington, Idaho, Nevada, Montana, Utah, and New Mexico. They are a combination of public lands administered primarily by the Bureau of Land Management, national forest lands administered by the U.S. Forest Service, private lands, State lands, and Indian lands. Some two-thirds of the PGRAs are extensively intermingled with private, State, Indian, and national forest lands. In Nevada, eastern Oregon, Utah, and southwestern New Mexico, the PGRAs are managed primarily by BLM. Where an intermingled land pattern exists, that is, where public lands administered by BLM are intermingled with private, State, Indian lands or lands administered by the U.S. Forest Service, the creation of economic leasing units and the exercise of proper land management practices can present problems. Proper management and conservation of the resource may require concurrent development of intermingled lands. However, with respect to private, State or Indian lands, there are no incentive or mandatory features in the law or regulations which provide for such joint development. Conflicting surface resources management objectives for Federal or other lands could act as a deterrent to geothermal development so adequate preleasing multiple-use resource management plans should be formulated, coordinated, and implemented.

The Geothermal Steam Act authorizes the leasing of public lands subject to such rules and regulations as are deemed appropriate by the Secretary. In formulating such rules and regulations, consideration has been given to the following alternative leasing plans and schedules and their potential resource development and environmental impacts.

a. <u>Open all but the excepted federally owned resources to leasing</u>

This form of leasing appears to be most consistent with the intent of the Geothermal Steam Act and it is the approach used for the proposed regulations. It is discussed here to facilitate comparison with other alternatives. Some 550 million acres of public lands would be available for exploration and potential leasing subject to appropriate environmental evaluations as set forth in Section 3200.0-6 of the regulations.

Geophysical, geologic, and geochemical information for geothermal resources is limited. While some 55 million acres of public lands have

been identified as having geothermal potential (KGRAs and PGRAs), there may be other areas having equal or better potential. Exploration and development of all areas could result in earlier and greater location, development, and utilization of geothermal resources to meet growing energy needs. Such development would offset the need for development of alternative energy sources that might be environmentally or economically less acceptable.

All potential developers would have access to all public lands except those excluded by the Geothermal Steam Act. Private sector exploration capabilities and interests could be fully utilized over the total area which would be conducive to earlier development and utilization of geothermal resources over a larger geographical area. While this alternative represents a minimum barrier to private sector exploration and development, it provides for adequate environmental protection measures and controls for all stages of resource development from initial exploration to full-scale production operations. It offers maximum latitude for full integration of geothermal energy sources into overall power industry energy planning and production and affords the widest range of development options.

Geothermal exploration could be conducted simultaneously with other resource exploration such as oil and gas. Multipurpose exploration could be less costly, it could result in better use of available exploration capabilities, and could reduce adverse environmental impacts that could result from separate sequential, single-purpose exploration efforts. Considerable geologic, geochemical, and geophysical information could be developed as a result of such exploration and development efforts even though economically producible geothermal resources are not found. Such information could be valuable for other mineral resources or land management purposes.

The proposed leasing plan could result in accelerated development of new technologies and systems to take advantage of resource potentials, particularly those not now of commercial value under existing technology. It also could be conducive to development of by-product systems or geothermal uses other than for power generation.

The opening of all of these public lands to exploration and lease application could be conducive to the filing for leases irrespective of real geothermal potentials since the areas subject to noncompetitive leasing would be available on a first filing basis. This could create an incentive to make the earliest possible application as there might not be a second chance for the area.

It also could create a situation subject to investment speculation and promotion schemes, some of which would be built on exaggerated hopes or claims of geothermal potentials or opportunities for windfall financial returns on investments. However, speculation could result under any leasing schedule.

There could be a flurry of exploration effort to delineate areas proposed for leasing, even though many of the areas have little or no geothermal potential. Such exploration could involve all of the environmental impacts as set forth in Chapter III, Section B-2. The urgencies for meeting lease application time constraints could result in accelerated exploration efforts and potentially greater immediate environmental impacts than might occur under alternative leasing plans which would delay or spread exploration activities over a longer time period. It is not possible to forecast the magnitude of exploration effort or the number of lease applications that might be received under this alternative. However, if all areas were covered by one application for the maximum area of 2,560 acres, as many as 200,000 applications theoretically could be possible. Realistically, there is virtually no possibility that this could happen since much of the public land appears to have little or no geothermal potential. Overlapping interests could increase the volume of applications, and lack of interest could decrease the volume. Intensive interest is expected in the more promising areas such as the PGRA lands. Lease fee charges and annual rental costs will serve somewhat as a barrier for lease applications, particularly for lands having little geothermal resource potential. However, large areas of public lands could be alienated at a minimum holding cost ($50 filing fee plus $1 per acre first year rental). In many instances, there probably would be no development. Other land and resource uses of such areas could be restricted due to the possibility of such development so long as such leases were held.

The proposed leasing plan could be the most effective approach to affording adequate opportunity for the electric power industry or other potential geothermal resource users to incorporate this energy source into their long-range plans. The identification of prime development areas could serve to focus land management agency land use, natural resource, and environmental protection planning efforts on those lands most subject to early development. However, such leasing could impose problems relative to agency capabilities to accomplish such planning and to take the actions required to meet lease application and resource development impacts. However, under the proposed regulations, the land management agencies have adequate opportunity to do the necessary preleasing procedures as set forth in Section 3200.0-6 and to develop the necessary surface management requirements as provided for in Subpart 3204. Subpart 3209 provides the measures necessary to assure that exploration measures are properly conducted. Even though the leasing initiative is with the applicant, the land management agencies will have adequate opportunity to take those actions and initiate such controls as are necessary to most effectively provide for development of geothermal resources in appropriate harmony with other land use and natural resource values and to adequately provide for protection of the environment.

Land use, natural resource, and environmental information may not be fully available for all areas for which lease applications may be received. The making of prelease evaluations and lease stipulations decisions will be more difficult in such situations, but leasing will not take place unless resource development can be accomplished in an environmentally safe manner.

Environmental Impacts. Opening of all public lands to exploration and leasing could result in environmental impacts generally proportional to the number of operations involved. All of these lands could be subject to exploration regardless of their geothermal potential. They could be exposed to the various potential environmental impacts as discussed in Chapter III, Section B-2, of this statement.

The greater the number of simultaneous actions and the wider the geographic distribution of such activities, the more difficult it could be for Federal agencies to monitor, supervise, and enforce regulations and stipulations. Specific evaluation of such impacts cannot be forecast but the environmental exposure would increase in direct relation to the volume, nature, and geographic distribution of exploration and leasing activity.

The qualifications and capabilities of individual operators also could be a significant factor. Reputable operators can be expected to adequately comply with all environmental protection requirements. At the other extreme, there probably will be operators who may tend to ignore certain environmental requirements due to lack of capability, desire to avoid costs, or for other reasons. However, the bonding requirements included in the regulations are designed to assure compliance with environmental stipulations and, in those instances of noncompliance, appropriate corrective measures can be taken, but there still could be some degree of environmental damage that could have been avoided with full compliance.

b. Lease only those lands classified as Known Geothermal Resource Areas (KGRAs) and Prospectively Valuable Geothermal Resource Areas (PGRAs)

This alternative could involve some 55 million acres, an area equivalent to about 10 percent of the area that would be available for leasing under the proposed regulations. As many as 20,000 applications could be involved if a 2,560-acre application were made for each part of the entire area. While heavy leasing interest is expected in these areas as a result of the existing geothermal classifications, it is not possible to forecast how many applications will be received. (Initially, leasing is proposed for only three areas in California.) It is highly probable that lease applications would not be received for all lands. There also could be multiple applications covering many of the lands within the KGRAs and PGRAs. On an acreage basis, there probably will be a greater intensity of applications for this 55 million acres than would be expected for the 550 million acre proposed leasing program. Environmental impacts generally would be directly proportional to the number of applications, land area involved, and the diligence with which development would be pursued.

Limiting leasing to KGRAs and PGRAs probably would tend to concentrate exploration and development activities to what appear to be the most promising areas for development under existing technologic and economic

conditions. It still would afford considerable opportunity for all parties with a genuine interest in development to secure leases. Competitive leasing is required for KGRAs and may be required for the "halo" areas around KGRAs if there is competitive interest. The fact that a KGRA has been identified may be considered as being sufficiently indicative of the potential resource value of such lands that competition will result. Where competitive interest is not shown in the form of overlapping applications, leasing would be on a noncompetitive basis. 1/

Leasing would be at the convenience and initiative of the Government. This alternative might provide better opportunity for land management agencies to develop timely leasing plans for those areas that may be most subject to early development and production. Such planning must include provision for other land uses, other natural resources, and for environmental values. Concentration of efforts on a smaller geographic area might facilitate earlier and more adequate identification of potential conflicts or problems as a basis for determining the appropriate leasing actions and environmental protection measures that should be required.

Under this alternative, exploration activities could be limited to the KGRAs and PGRAs or they could be permitted on all public lands. There could be significant advantages to permitting exploration of other lands as such exploration could identify prime target areas that should be classified for leasing and early development to gain the potential energy and environmental benefits of geothermal resources as an alternative to other energy sources.

Since these appear to be the most promising areas, exploration and leasing for development might concentrate private sector efforts which could result in earlier production from such resources. The potential of other areas subsequently could be determined and development programmed to meet industry or area energy needs consistent with overall land use, natural resource, and environmental objectives.

There also could be greater possibility that technical data may be available, or could be obtained within reasonable timeframes, to make prelease evaluations consistent with lessee development plans and timetables. Lack of technical data could restrict or delay development of appropriate lease stipulations and environmental safeguards, but confining leasing in this manner would allow for concentration of capabilities on what appear to be areas of highest potential based upon currently available information.

1/ Such as defined in Section 3200.5(3) of the proposed regulations.

The concentration of known or potential geothermal resource sites mostly is in more remote areas removed from population centers. The KGRAs and PGRAs lie primarily in areas presently being used for activities such as domestic livestock grazing, wildlife habitat, recreation, sustained yield timber management, residences, extraction and processing of hard-rock minerals, and agricultural production.

PGRAs in Nevada are generally public lands which are arid and undeveloped. The land is primarily used as livestock range and wildlife habitat. The same is generally true with respect to the limited PGRAs in Arizona. There is some agricultural production in Arizona in some of the 21 identified PGRAs which do not contain KGRAs.

California presents a different problem. The PGRAs in southern California are intermingled with private lands and some are entirely comprised of private holdings. Residential, recreational, and agricultural uses predominate in southern California. Agricultural use generally is dependent upon irrigation systems. The geothermal resources in southern California generally are considered to belong to the wet steam system which will require the withdrawal of a large amount of saline fluids and the need to reinject or otherwise dispose of spent fluids. The Imperial Valley KGRAs are discussed in detail in Volume II of this statement.

The PGRAs clustered on the western slopes of the Sierra Nevada Mountain range are removed from population centers. The majority of these lands are included in national forests and Los Angeles watersheds. They also are subject to high recreational use. The Mono-Clear Lake KGRA is discussed in detail in Volume II of this statement.

The PGRAs in northern California fall into two distinct geographic areas. One is The Geysers area, which is discussed in detail in Volume II of this statement. The other area is in the northeastern corner of California adjoining Oregon and Nevada. Here the land ownership pattern is intermingled private, national forest, and public domain. The population is generally sparse and the lands have significant recreation values. This area is principally used for livestock grazing and wildlife habitat, with some dry farming. The California portion of the PGRA includes four KGRAs. The PGRA extends into Oregon and Nevada. The Oregon portion includes three KGRAs near the California-Oregon-Nevada boundary.

In New Mexico, the PGRAs are concentrated in two areas, one in the vicinity of Albuquerque and Santa Fe and the other in the southwestern portion of the State. The northern PGRAs contain the only KGRA in the State. It is believed that this KGRA contains a dry geothermal steam system. No other dry steam system is known to exist in the United States outside The Geysers

in northern California. This suggests that this KGRA could hold great prospect for immediate development since the state of the art is most advanced for the dry steam system and there is a need to augment the present energy supply for the expanding Albuquerque metropolitan center.

The northern PGRAs have an intermingled land ownership pattern. The public domain administered by BLM is intermingled with Indian lands, national forests, and private and State lands. The area is subject to many different uses, including residential, recreational, timber harvesting, agricultural, and mining.

Environmental Impacts. The limiting of leasing to KGRAs and PGRAs might afford a better opportunity for timely evaluation, planning, programming, monitoring, and control for all geothermal operations to assure acceptable environmental protection. Agency efforts could focus on those areas most subject to early resource development. The potential environmental impacts of geothermal exploration and development are discussed in detail in Chapter III, Section B. Detailed evaluation of potential environmental impacts for the three areas initially proposed for leasing are included in Volume II of this impact statement.

Generally, the impacts will be in direct relationship to the number of operators, land area, and environmental settings involved. At least on a short-range basis, potential impacts could be less than under the proposed program since only 10 percent of the total land that could be leased would be subject to leasing under this alternative. However, at least part of this difference would be offset by the fact that the KGRAs and PGRAs have been identified as those areas of greatest resource potential so exploration and leasing interest probably will be heaviest for such lands.

In actual practice, there should not be a significant difference in adverse impacts as the proposed regulations provide for adequate environmental control measures for all exploration activities and for preleasing procedures that afford land management agencies the appropriate opportunity to consider all land, resource, and environmental values. No leases will be issued if it is not felt that development can be accomplished in an environmentally safe manner. In those instances where adequate information is not available to make such determinations and to prescribe appropriate environmental protection measures, the issuance of leases will have to be delayed or limited until such time as adequate information can be obtained and appropriately utilized.

c. Lease only those lands classified as Known Geothermal Resource Areas (KGRAs)

This alternative would limit leasing to approximately 1 million acres of Federal lands that are included within the 1.8 million acres currently classified as KGRAs. (See Chapter II-B and Appendix H.) These are the areas which have been identified as having the highest geothermal resource

potential based upon currently available information. Generally, most of the discussion relative to Alternative b covering KGRAs and PGRAs would be applicable to this alternative but on the basis of about 2 percent of the acreage discussed in that alternative.

Under this alternative, more precise evaluations and plans might be possible in advance of lease offerings. This could facilitate land use, natural resource and environmental planning and actions, and possibly more effective allocation of resources based upon factors such as geothermal technology relative to individual lease sites, energy demand and economics, and specific environmental considerations.

There could be heavy competition for the limited acreage available. Leasing would be by competitive bidding. The limited area could result in high bids that might limit or exclude potential developers. If initial bid costs were high, the capital requirements could result in delay in development or limited budgets which could result in operations that might tend to cut corners, particularly relative to environmental protection measures that may increase the costs for development and operation. This could result in problems in achieving environmental compliance.

Limiting the number of potential operators also could restrict the development of technical data and the research required to achieve more effective and environmentally safe use of geothermal resources in these and other areas. Development of geothermal potentials could be significantly delayed, thereby requiring the development of alternative energy sources that could have more severe environmental impacts.

Environmental Impacts. The potential environmental impacts would be similar to those described under Alternative b, but under a limited program of this nature all environmental protection actions could be closely supervised and enforced. Experience gained from such operations subsequently could be utilized when leasing was expanded to other areas. From an immediate geothermal development standpoint, this alternative might involve less adverse environmental exposure but the impacts of developing alternative energy sources could far outweigh such benefits. This largely would depend upon the amount of time that would elapse before additional geothermal leasing was permitted. A delay of a few years might not be too significant, but a long delay would require that firm commitments be made to other electric energy sources.

d. Lease only Federal geothermal resources in connection with adjacent, adjoining, or nearby private and State land geothermal resource development to complete economic units

Presently, private geothermal development is concentrated in California, Oregon, Idaho, Nevada, and Arizona. Except for The Geysers area of California, private development is minimal or only beginning. In most cases outside The Geysers and Salton Sea KGRAs, present geothermal

development does not involve generation of electricity as the primary objective. For example, Klamath Falls, Oregon, uses geothermal heat for space heating.

Private land resources may be developed regardless of Federal leasing policies. If Federal lands were not available, there might be greater or less incentive to develop private land resources. This alternative primarily would provide for Federal/private land development units. The land pattern in many of the existing developed areas is scattered with isolated tracts of Federal lands, including reserved mineral interests, many of which do not lend themselves to economical units for geothermal resources exploration and development purposes. Failure to make these scattered lands available concurrent with exploration and development of intermingled private lands could result in loss of the geothermal resource therein—either as a result of drainage from adjacent private lands development or because the resource would be passed over due to the depletion of the resource from the adjacent private lands. The leasing of adjacent Federal lands could enhance both public and private land potentials by forming logical production units.

New technologies and systems probably would be developed to more effectively utilize private land and related Federal land resources. Such technology then would become available for use in developing major Federal land ownership areas at a later date. This could result in more efficient development and use of Federal land resources. However, there probably would be less research incentive under this alternative than would result under less restrictive leasing plans which offer a greater variety of sites and acreage for development.

A limited leasing program such as this might be more subject to public acceptance as the impact of geothermal resource exploration in the specific areas on private lands has or will have occurred. Further exploration on adjacent, adjoining, or nearby available Federal lands probably would not materially impact adversely on other resources or conflicting uses due to previous exploration activities on private lands. The land management agency could benefit from the experience gained from operations on private lands, thereby helping to assure that leases would include all lease terms, conditions, and special stipulations required to protect the environment, to mitigate adverse impacts, to provide for proper reclamation, to conserve the resource, and to protect public interests. Experience gained could be applied to a subsequent expanded leasing program as appropriate. Agency capabilities could be developed and scaled up consistent with planned leasing workloads.

The development of federally owned geothermal resources would be delayed until adjacent private lands were considered for development. Uncertainties as to the availability of Federal lands could hinder or prohibit adjacent private land development. Some of the more promising Federal areas may have little or no adjacent private land subject to development so potential energy source benefits would be deferred or not developed.

Geothermal resource development would be delayed or might not be used to meet a part of the rapidly growing energy need even though such use might be less costly and more environmentally acceptable than the alternative energy sources that would have to be developed.

Under such a program, the development initiative would rest with the private landowner and/or developer. The Federal Government generally would be in a reactive role subject to the timing of private land development. It would not be offering other areas of high geothermal potential for development to meet a portion of energy needs.

There would be no incentive for exploration of most public land areas since they would not be subject to leasing. Classification and management planning for public lands with potentially significant geothermal resources would be delayed due to the uncertainties of determining geothermal potentials, lack of geothermal information, and the timeframe within which public lands might be offered for development.

Environmental Impacts. Whether or not Federal lands are leased, the impacts of development probably will occur on adjacent or nearby private lands. In such instances, the environment has already been exposed or conditioned to geothermal resources development. Where development of private lands takes place, the inclusion of adjacent Federal lands would only extend the area of such impacts. Inclusion of Federal lands could result in environmental protection practices that also would improve environmental protection on the related private lands as private landowners may be inclined to impose less stringent environmental controls and reclamation requirements than the Federal Government will require on the adjacent or nearby lands it leases.

e. Lease areas of greatest potential relative to electrical energy needs

The most immediate need for a geothermal resources leasing program appears to be for generation of electrical power to supplement regional or local energy supplies. The use of geothermal resources for other purposes such as for space heating, product processing, agricultural heating, or desalination, either of the geothermal fluid itself or of other saline waters that may occur near or be transported to a source of geothermal energy, appears to have less economic potential at this time and may not occur in the near future.

Another alternative for initial leasing could be in KGRAs near areas experiencing the most acute and urgent need for electrical energy. Initially such a program would be limited to California and possibly Nevada, Arizona, and New Mexico. Private development to date has been concentrated in these States, especially in California. This is the situation that exists relative to the three California areas proposed for leasing at this time. (See Volume II for detailed discussions of these three areas.)

This alternative would permit the timely processing of lease applications to provide for early issuance of leases so exploration and development can begin and development could be planned relative to area electrical energy needs. It would take advantage of industry's initiatives and interests for development and would permit potential developers to plan for the acquisition of adequate reserves to warrant commitment to geothermal development and power production. Savings could result from eliminating the need to develop more costly and probably more environmentally damaging sources for an equivalent amount of electrical energy. Overall system planning could be facilitated.

Development of geothermal resource potentials of other areas would be delayed. While local needs for additional electrical energy may not be as great, the supplementing of local supplies could relieve pressures on subregions which in turn could have beneficial impacts within the region. For example, southern California gets much of its electricity from the Pacific Northwest. Such potential benefits would be foregone.

Development would tend to be limited to major developers or users with little opportunity for smaller operators due to higher initial leasing costs.

There would be slower development of technical data and technology due to the limited areas available under this alternative.

Environmental Impacts. To the extent that geothermal resources are not developed, areas will have to develop alternative sources of energy equivalent which could be subject to greater adverse impacts. The three areas proposed for leasing are major examples of this alternative as the energy produced would impact on the San Francisco and southern California areas. The environmental impacts would be of similar nature to those set forth for the individual areas discussed in Volume II of this statement but they would vary depending upon the local environmental setting, the nature of the geothermal resources, and the intensity of development.

f. Prototype leases for one or more major geothermal areas

Leasing units would be selected by the Government, probably on the basis of nominations received from industry. This alternative could focus on the leasing of areas with the most promise, the least potential adverse environmental impacts, and/or areas that would provide the best opportunity for developing and testing geothermal power production systems. These areas would be leased under terms which would assure early development to gain the benefits to be derived from prototype or pilot plant operations.

Prototype leasing could permit orderly testing and evaluation of all phases of development which could be useful in subsequent, more comprehensive leasing programs. The Government would gain experience and information on various geothermal resources systems with respect to environmental impacts, management practices which might facilitate resource use consistent with protection of other resource values, compatibility of geothermal resources development with all other uses of the land, maximum conservation and recovery of the resource, subsidence and seismology effects due to the withdrawal of fluids from the reservoir, etc. Such information could facilitate the development of other similar geothermal resource areas. However, it might have limited value for dissimilar resource and environmental situations.

Such a leasing program could be used to develop and test processes for recovery and use of geothermal resources from the various systems, i.e., dry steam, wet steam, dry hot rock, etc. Under existing technology and systems, early production likely will occur only from dry steam fields or hot water systems where most of the experience exists. Industry could be reluctant to invest substantial sums of money at an early date in unproven methods or systems. Prototype leasing could provide opportunities and incentives through actions such as deferred bonus payments, offsetting of all or part of the bonus and/or rentals in return for guaranteed expenditures, and development allowances for unusual environmental costs, etc. There could be direct Federal participation in research needed primarily for the Government's use to improve resource information and/or environmental protection.

A major consequence could be extension of the development of technology and technical data over a longer timeframe with a corresponding delay in the development of geothermal resources to meet energy needs. Prototype leasing could limit development on public lands to a few operators, probably larger ones. Others would be excluded from the opportunity to develop public land resources until such time as an expanded leasing program was offered.

Environmental Impacts. Because of the limited nature of a prototype leasing program, this alternative probably would have the least immediate environmental impact of the leasing alternatives. Under this alternative, the Government would select the tracts to be offered for lease and would closely control the operations. Specific environmental impacts should be minimal due to such controls. They could vary by the site, the nature of the geothermal resources, and the utilization processes employed. The Federal leasing commitment would be limited to the scope of the prototype leases. Future leasing could embody the environmental knowledge and protection measures developed from the prototypes so subsequent leasing impacts might be reduced in those instances where similar conditions exist. However, similar benefits could be obtained from any leasing program as experience gained on each operation could be applied to other similar operations.

g. Issue leases to honor only "grandfather" rights for conversion to geothermal leases and to applications for geothermal leases

The Geothermal Steam Act provides that mineral leases and permits and mining claims which were outstanding on September 7, 1965, may be converted to geothermal leases, and that applications for mineral leases and permits which were pending on September 7, 1965, may be converted to applications for geothermal leases. As a result of this conversion or "grandfather" right, 47 conversion applications were filed, of which 31 are located on KGRAs. The applications involved lands in California, Nevada, Oregon, and Utah. A total of 72,562 acres are embraced in these applications, of which 55,039 acres are located within KGRAs. Table IV-1 shows the acreage distribution of these applications by States and type of mineral classification. The lands involved in the "grandfather" applications are scattered throughout four States. Coincidentally, these areas tend to correspond to areas having the most urgent need to augment the local electrical energy supply. The applications embrace lands in six different KGRAs. Table IV-2 shows the distribution of applications by KGRA.

Limiting the initial leasing program to "grandfather" lands would take advantage of previous efforts of industry which pioneered the search for and development of geothermal resources. This provision of the Act was incorporated into the statute to recognize the interest and rights of those who had made substantial expenditures for the exploration, development, or production of geothermal steam on the lands for which a conversion is sought or on adjoining, adjacent, or nearby Federal or non-Federal lands.

Some of the potential environmental impacts have already occurred from these pioneering activities. It is possible that there has been public acceptance of the activity and that this past exploratory and development activity was generally compatible with the uses of the land.

By virtue of the provisions of the Geothermal Steam Act, the "grandfather" applicants have reason to believe that the lands they applied for would be leased at an early date. While the Act does not state that such leases are to be issued first, or even given priority, the fact remains that the conversion of "grandfather" rights had to be exercised within 180 days after passage of the statute, suggesting that Congress intended relatively early conversion to geothermal leases.

Under this alternative the Government could have no options with respect to what lands should be leased first. Lands potentially even more valuable for early development may exist, but they would not be made available for development even as a possible alternative to "grandfather" areas. However, this alternative, it is believed, would allow the leasing of lands involving three geothermal resources systems which could provide a variety of development experience for appropriate subsequent leasing of other areas.

Table IV-1. "Grandfather" Right Applications and Acreage

State	No. of applications	Total acres in applications	Acres within KGRAs	Acres outside KGRAs
California	38	61,792	50,466	11,325
Nevada	5	7,468	4,452	3,017
Oregon	1	1,460	0	1,460
Utah	3	1,842	120	1,722
Total	47	72,562	55,038	17,524

Table IV-2. Distribution of "Grandfather" Right Applications by KGRA

KGRA	State	No. of applications	Acreage
The Geysers	California	14	12,097
Mono Lake-Long Valley	California	8	30,521
Salton Sea	California	5	7,078
Coso Hot Springs	California	1	770
Brady Hot Springs	Nevada	2	4,452
Roosevelt	Utah	1	120
Total		31	55,038

A leasing program involving only "grandfather" application lands probably would, in some instances, require leasing of additional peripheral lands in order to create economic leasing units. The acreage of the median "grandfather" application is 1,101 acres. This might not constitute an economic development unit. Consequently, peripheral lands surrounding the applications might have to be made available for leasing at the same time the "grandfather" leases are issued. There could be problems to assure that additional lands adjacent to "grandfather" leases outside of KGRAs were available to these lessees if such lands were required to permit operations. Non-KGRA peripheral lands around the "grandfather" applications would be open to simultaneous filings. KGRA lands would be subject to competitive bidding. This would mean the "grandfather" lessees would have to take their chance against other applicants in obtaining a lease to peripheral lands to make up an operational unit. Delays in development also could occur where negotiations are necessary between adjoining lessees to create economical leasing units, either though unitization, communitization, or assignments.

A further potential limiting factor is that of the acreage involved in "grandfather" applications in The Geysers KGRA. About 6,700 acres or 55 percent of the area covered by "grandfather" applications are reserved Federal mineral deposits. The issue of whether a reservation of "all minerals" in patents received from the Federal Government includes geothermal resources presently is in dispute and is the subject of a pending court case. They could be offered with the understanding that receipts be held in escrow until final court resolution.

Environmental Impacts. The environmental impacts in three of the KGRAs involved in "grandfather" or conversion rights are discussed in detail for the three areas proposed for leasing (see Volume II of this statement). These three KGRAs embrace 27 of the 31 "grandfather" applications within KGRAs. The remaining four "grandfather" applications located within KGRAs include one small area in Utah embracing 120 acres, one area in California embracing 770 acres, and two areas in Nevada involving 4,452 acres which could possibly be economic in terms of size.

The Nevada applications are included in the Brady Hot Springs KGRA. This KGRA is located on public lands and appears free of intermingled lands, although some private land holdings exist in the area. Livestock grazing and wildlife habitat are the primary uses of the land. These uses are compatible with geothermal resources development but may be curtailed or eliminated once production is achieved.

The population in this area is generally sparse, and the KGRA is far removed from any significant population center. This area has far less population than the other four KGRAs in California; therefore, "grandfather" area geothermal resource development in the Brady Hot Springs

KGRA would have less impact on people than any of the four KGRAs in California. Even if peripheral lands are added to the lands under "grandfather" applications, the character of the lands and the nature of the use of the surrounding lands would not be materially different from the KGRA lands

h. Prospecting permit leasing program

This alternative would provide for geophysical work under a "Prospecting Permit" for non-KGRA lands before leases would issue. The exploration operator would be given permission to prospect for geothermal resources for a period of time such as 6 to 12 months to provide adequate time for completion of necessary exploration work. He would be limited to an area such as three townships under each Prospecting Permit. The permission granted by the permit would be exclusive. All exploratory information obtained would be made available to the Federal Government.

Once the exploration operations were completed, the Geological Survey could classify the land. If any of the lands were determined to be a KGRA, such lands would be offered for competitive lease. If the lands were non-KGRA, the exploration operator would be given the opportunity to acquire a noncompetitive lease without having to compete with others. The exploration operator could select any area he wanted to lease within the three townships explored up to the maximum allowable acreage in a State, provided the selected lands are in a developable unit. The option would remain with the Federal Government to exclude selected lands because of unacceptable adverse environmental consequences of geothermal development. All lease applicants and successful bidders could be required to submit a plan of operations setting forth a viable development program commencing with the second lease year.

The Federal Government would have the benefit of all exploratory information for making environmental evaluations and for developing lease terms, conditions, and special stipulations. The prospective lessee would be more adequately informed as to lease stipulations for preparing a plan of operation.

Development activity on leases might be channeled into the most promising areas since it may be unlikely that an exploration operator would take a lease where his exploration operations revealed little potential. Development could take place at an early date since the lessee already would have a substantial exploration knowledge and investment.

Where non-KGRA lands are leased, there would not be opportunity for all interested persons to acquire a lease. In effect, this alternative would give a preference right to a noncompetitive lease by virtue of the exclusive "Prospecting Permit" issued in advance of exploration. However, if the area was classified as a KGRA, others could bid for the lease even though they had done no exploratory work.

Environmental Impacts. From an environmental standpoint, the main features of this alternative are the limiting of exploratory operations to one for each selected area and the availability of all exploratory information for lease consideration and other land, resource, and environmental actions. Environmental impacts associated with exploration could be more subject to close control and protection compliance since activities would be limited to a single operator who could be held responsible for all related impacts. By contrast, where there are simultaneous multiple-operator explorations under competitive lease application time pressures, less care might be exercised to protect environmental values and, where more than one operator conducts activities in an area, responsibility and restoration liability would be harder to establish. In some instances it might not be possible to determine which operator caused the environmental damage.

More complete exploration might result under a "Prospecting Permit" system since the operator would be afforded adequate time to explore the area without having to compete with others in filing an application for a lease. Since the exploratory information would be made available to the Government, preleasing evaluation, planning, and the development of appropriate lease, environmental, and other stipulations could be facilitated. Operators also should have a better basis for development of operating plans, including appropriate environmental protection measures.

i. Preleasing nomination system

This alternative would provide for nominations from potential geothermal resource developers. Such nominations would be periodically called for on a statewide, area, or other appropriate basis. The notice would invite the public to select those blocks of land that they would like to have offered for lease. Blocks also could be selected by the Government on a schedule or plan basis.

Upon receipt of nominations, appropriate environmental and other evaluations would be made to determine the areas to be offered for lease. Lease conditions and stipulations could be developed in advance of leasing to advise potential lessees as to the major provisions of such leases. The Government then would select the areas to be offered. Lands within KGRAs or areas covered by multiple nominations would be offered by competitive bidding. Other lands would be subject to noncompetitive leasing as provided by the Geothermal Steam Act. Offered lands would be in economic leasing blocks based upon available geothermal reservoir and other available information.

Such a system might be conducive to early geothermal development since selection of tracts through the nomination process could focus exploration, evaluation, and development efforts on those areas in which potential developers have shown interest.

Environmental Impacts. To the extent that earlier development of geothermal resource potentials are realized, there could be environmental advantages from the standpoint of avoiding the need to develop alternative electrical energy sources that could be environmentally more damaging. Since both private sector and governmental interests and capabilities would be focused on those areas which probably would be most subject to early development, maximum attention could be given to all environmental protection considerations for the area involved. Leasing would be at the convenience of the Government based upon nomination evaluations. This could allow fuller opportunity for obtaining all information required to assure that development would be done in the most effective and environmentally acceptable manner.

There still would be adequate opportunity for the conduct of exploration activities to permit prospective lessees to do the necessary work required as a basis for tract nomination. Exploratory information probably would not be available to the Government since it could be considered as being of a proprietary nature to individuals who subsequently might have to compete in bidding for leases. This could be a disadvantage relative to alternatives that could require that such information be furnished to the Government for its use in resource evaluation activities since there can be environmental advantage associated with any such information.

j. Maximizing competitive leasing for nonclassified lands

Under this system, issuance of one or more noncompetitive leases in an area could result in the establishment or creation of a potential geothermal resource area (PGRA). This area could be determined to be all the land within a designated area such as one having boundaries which are 5 miles from the most northerly, easterly, southerly, and westerly boundaries of the tract or tracts included in the noncompetitive leases. Once the PGRA was defined, the issuance of geothermal leases on a significant portion of the area such as 10,000 acres in a PGRA or one-quarter of the available Federal lands within the PGRA would be considered demonstration of sufficient competitive interest to warrant competitive leasing for the remainder of the PGRA. The PGRA would then be classified as a KGRA. Subsequent leasing then would be by competitive bidding.

Upon issuance of the initial lease, preliminary evaluations could be made of the PGRA to provide for subsequent lease actions. When the PGRA was classified as a KGRA, the Government would be in a position to complete preleasing evaluations for the entire area before lands are offered for competitive leasing. It also would permit the successful bidder to formulate a definite plan of operation at an earlier date.

Under this alternative there could be an early filing rush in an attempt to obtain the maximum allowable acreage noncompetitively as subsequent leases could be more costly or even not obtainable to some interested parties due to competitive bidding factors.

Competitive leasing would be based upon Federal selection and offering and/or private sector nominations. Leasing would be at the discretion of the Government so there could be fuller opportunity for adequate pre-lease planning; accumulation of necessary land use, natural resource and environmental information; the making of evaluations; and the formulation of lease stipulations and environmental protection requirements for inclusion in lease offering information and in the subsequent lease stipulations. This could improve overall land and resource multiple-use planning and action programs and reduce the uncertainties of unknowns relative to proposed leases. It could be conducive to offering of the most promising geothermal lands for early geothermal resource development. Operators could be fully aware of major land, resource, and environmental plans and requirements which could facilitate their development of operating plans for review and approval.

Competitive leasing might restrict the number of lessees as a result of higher bids and initial leasing costs. Competitive bidding might attract those most interested and capable of early development and utilization of geothermal resources. Smaller operators with less capital might not be able to compete, particularly for the more promising areas. From an environmental standpoint, this might be advantageous as those with adequate financial resources and development capabilities could be in a better position for taking all measures necessary to protect and accommodate all land use, resource, and environmental values. However, competitive bidding also could result in leases where the lessee has committed so much of his capital to the obtaining of the lease that financial constraints could impair his ability to develop the geothermal resource potential in the most environmentally acceptable manner.

Competitive leasing might tend to discourage preleasing exploration since there would be no assurance that those doing the exploratory work would be the successful bidder. Due to lease uncertainties, those conducting exploration activities could tend to limit costs which in turn could result in greater adverse environmental exposure from such operations. There could be incentive to apply for leases with little or no advance exploration since first year costs would be nominal. Exploration work to be accomplished after a lease has been issued would be covered by lease provisions requiring appropriate environmental protection measures.

Environmental Impacts. Noncompetitive lease applications, prior to KGRA classification, could be based on limited geothermal resource information, particularly if there was a rush to obtain leases on a noncompetitive basis before areas were classified as KGRAs. Hurried exploration could pose greater environmental risk than might result if most of the area was subject to noncompetitive leasing. Little might be known about other land, resource, or environmental values. Leases might be issued with minimum of initial stipulations subject to subsequent revisions as necessary as exploration and development progresses and as more complete evaluations could be made. Assuring adequate environmental protection

for the initial noncompetitive leases could be more difficult due to the uncertainties that may exist. There could be little incentive for early exploration and development once a noncompetitive lease was issued, particularly if such leasing was of a speculative nature awaiting further leasing activity.

This alternative could be conducive to earlier identification of promising geothermal areas which in turn could result in earlier production that could offset the need to develop an equivalent alternative energy source that could be environmentally less acceptable. Once the initial leases were issued, the Government would control subsequent lease offering actions since competitive offerings would be at the convenience of the Government. Information could be obtained from initial noncompetitive leases which could facilitate the environmental evaluations and preparation of lease stipulations to assure environmentally safe operations.

k. Noncompetitive leasing for all areas outside of KGRAs and PGRAs

Approximately 1 million acres of Federal lands have been classified as KGRAs and 54 million acres are classified as PGRAs. This leaves over 500 million acres of leasable public lands as not now being considered as having significant geothermal resource potential. It is possible that these lands may not be subject to significant exploration effort unless some incentive is offered to encourage exploration ventures. Even though present geologic information does not indicate geothermal potential, there could be resources areas that have not been discovered. Similar situations have existed relative to oil and gas where wildcat exploration efforts have led to significant discoveries.

Under this alternative all areas outside of KGRA and PGRA classified areas would be offered for noncompetitive leasing irrespective of the number of applications that might be received for any one area. Priority for overlapping applications would be determined by the filing date of applications. Applications filed the same day would be subject to drawing for lease award. There would be no restriction on when an application could be filed. The lands would be continuously opened to filing and leases would be issued on a first-come basis. Applications could be filed without requiring the first year's advance rental to accompany the applications. Such rental would be required when a lease issues.

To encourage exploration and leasing, annual rentals could be fixed at the statutory minimum of $1 per acre for the first 5 years. Diligent exploratory operations could be required to begin no later than the sixth year. Lease extension after the primary 10 years could be subject to evidence of diligent development effort.

As a further incentive, lessees could be permitted to enter into a development contract, approved by the Secretary, which could provide relief from acreage chargeability or allow that diligent exploration performed on one or more of the leaseholds involved would satisfy the diligent exploration requirement.

Leases could be issued upon application after completion of area-type environmental analysis. Such analysis, in combination with agency land and resource management plans, would provide the information required for formulating the general and specific environmental stipulations to be included in leases. Each lease could contain a provision that would permit the Government to add or modify stipulations as work progresses and evaluations indicate the need for additional protection measures. Lessees would be required to furnish all exploratory and other information to the Government. They also would be required to submit operating plans for all phases of their operations. Such plans would be subject to approval before operations would be permitted.

Exploration and development activities would be subject to appropriate monitoring to assure compliance with lease stipulations, approved operating plans, and operating orders. If potentially unacceptable environmental impacts were detected, corrective measures would be required. If such were not possible, no further operations would be permitted.

Under noncompetitive leasing, potential developers might have more incentive to secure a lease at the earliest possible date to protect themselves against filing by others. They would have the advantage of tenure beginning with the filing of their application. This could allow time for more complete development of exploration and development plans, possibly simultaneously with Government processing of the lease application. Such a simultaneous effort could be conducive to more fully coordinated Federal and lessee plans as issuance of leases could be timed to allow for all necessary preleasing actions. So long as the lessee's rights to a lease were protected, there might be no adverse effects from delaying actual lease issuance until the necessary preleasing evaluations, lease stipulations, etc. had been completed. The applicant would be able to continue exploration efforts and interim permits for portions of development activities could be issued as appropriate subject to subsequent modification.

Environmental Impacts. Potential environmental impacts generally would be similar to those associated with the proposed program. Noncompetitive leasing would allow for participation by the greatest number of potential lessees. This could accelerate the rate of resource discovery and development. It also could result in greater environmental exposure due to the number and wide geographic distribution of exploration and development activities. To the extent that development is accelerated or delayed, the development of equivalent energy sources would be correspondingly affected. Where such alternatives are environmentally more damaging then geothermal development, there would be corresponding environmental advantages or disadvantages.

Under a noncompetitive leasing system, leases would be issued on a first application basis. The addressing of many land use, resource planning, and environmental issues, and the submission of operating plans, might have to be delayed until after applications were received and possibly after leases have been issued. However, there still would be adequate opportunity to develop necessary environmental protection measures and stipulations for inclusion in leases and operating orders. Overall land and resource multiple uses might be subject to more problems than might result under a competitive bidding or tract nomination system where planning and evaluation work was accomplished in advance of leasing.

The nominal initial investment associated with noncompetitive leasing could be conducive to exposure to a wider variety of potential lessees ranging from serious and capable developers to speculators with little or no interest, capability, or actual intent of personal development. Potential environmental impacts and their relative severity likewise could vary widely with the greatest impact potential being with those least qualified to perform exploration and development activities in an environmentally acceptable manner. While it is possible to control such activities through exploration and lease procedures and stipulations, surveillance and enforcement become more difficult with marginal operators, particularly when they may range over wide geographic areas.

3. <u>Alternatives for Exploration and Development of the Resources</u>

Geothermal resource exploration and/or development on the public lands could be accomplished by the private sector, by the Federal Government, or by various combinations of Federal/private joint or cooperative efforts.

The proposed leasing program provides for the private sector performing those exploratory activities as are considered necessary by individual operators for evaluation of resource potentials prior to leasing, for filing of applications for noncompetitive leases or for competitive bidding, and for preleasing development planning. This affords maximum opportunity for potential lessees to develop whatever information as is needed within the timeframe of their individual plans or operations. Individual operators would not be dependent upon exploratory information developed by others which might not meet their information or timing needs. Even where information of this nature is available, there may be need for individuals to verify it or develop additional detail relative to their particular needs. Accordingly, private sector exploration could be more conducive to earlier discovery and development of geothermal resources.

The nature and potential impacts of exploration activities are described in Chapter III, Section B(2). Mitigating measures for environmental protection are discussed in Chapter III, Section C(2). The following section presents considerations relative to alternative ways in which exploration and development could be accomplished.

a. Federal exploration and development

Geothermal resource exploration and development could be accomplished by a Federal agency or by a Government corporation. Such undertakings could be limited to general exploration, to exploration and general delineation of geothermal reservoirs, or they could include complete exploration and development testing to the point where knowledge of the resource and environmental factors would result in lease offerings of proven reserves. Potential resource and environmental advantages and disadvantages of Federal exploration and development within the broad range set forth above could be significant.

Under a Federal program, the Government would have absolute control over all exploration and development actions and their associated environmental impacts. The Federal Government and the public would have full access to all information.

Such exploration and inventory information on the location, quantity, and physical properties and quality of geothermal resources could be of significant value for assuring the most effective management of geothermal resources in harmony with other land uses and natural resource and environmental values. Under private sector exploration and development, such information may not be developed and company competitive factors could result in reluctance or refusal to disclose exploration plans or findings. Where such information is furnished to the Government, it may be considered to be privileged and not subject to public disclosure.

In addition to the geothermal resource and related environmental information obtained by Federal exploration activities, much geologic and other information might be obtained which could be of considerable value for environmental protection and management of other public land and mineral resources. A Federal program could provide for more complete collection and dissemination of such information. Private exploration probably would develop only that information directly related to geothermal resources. Other resource information not directly related to geothermal resources might not be developed or made available for other potential uses or users.

Private exploration and development could tend to highgrade resource opportunities for short-term economic return. A Federal program might be more conducive to systematic and complete area coverage to better identify both immediate and longer term resource potentials and significant environmental factors. It might result in the location and early development of a greater proportion of the total resource potential of each area. Under private exploration, areas passed over in the initial effort could be less subject to future exploration and development. Federal exploration would produce resource inventories that could be called upon when new technologies or changing economies made development economically and environmentally feasible.

Public land resources might have greater availability to all potential developers since leases involving better known resources would be subject to more positive advance identification of environmental constraints and requirements. Resources might not be as subject to private sector withholding due to speculation, resource or environmental uncertainty, or other reasons.

Overall, there could be greater total resource recovery from individual areas since the Government might be more fully informed as to the nature and extent of the geothermal resource and its potential for energy production as well as possible by-products of fresh water or minerals. Development of Federal geothermal resources could be better coordinated with private land geothermal resources as well as with other energy energy resources. More efficient recovery practices might be planned and implemented for entire areas. Significant environmental advantages could accrue from greater resource use efficiencies or recovery systems that minimize surface impacts.

There could be more orderly and environmentally safe development of Federal resources, particularly in areas where it might not currently be economically feasible for a single individual or company, or a combination of individuals or companies, to undertake exploration and development under existing or potential technologic, economic, land use, or environmental constraints. Exploratory information could provide a basis for future private sector development decisions.

Private sector exploration and development could be more conducive to earlier geothermal development in areas of greatest energy need since industry would be in control of the entire process from exploration to production. By contrast, Government programs might trend toward obtaining more complete geologic and other natural resource and environmental knowledge than is needed for geothermal resource exploration since such knowledge could be simultaneously developed to serve other purposes. While it would be of value for broader land use and resource programs, it could delay completion of the less comprehensive investigation needed for geothermal resources. Federal exploration could cover a broader area, including other mineral values, and could serve multiple purposes, thereby reducing the environmental impact by avoiding multiple single-purpose exploration efforts.

The rate of geothermal resource development could be reduced if Government efforts were oriented to full exploration of each geothermal area rather than concentrating on those areas having the greatest immediate economic production potential. In many instances, such potential might better be determined by those having the responsibility for developing and producing electrical energy from geothermal or alternative sources. Industry uncertainty as to the Federal exploration and development schedule, nature and intensity of effort, rate of proving of reserves, sales policies, etc. could result in industry decisions to invest in higher cost and/or less environmentally acceptable alternatives.

The exploration of private lands is a private sector function. Frequently intermingled or adjacent public and private lands need to be simultaneously explored and developed. Split responsibility could interfere with such development. The rate at which private land resources are developed could be reduced pending the timing and outcome of Federal efforts and the availability of Federal geothermal resources. Depending on private capital and initiative for exploration and development may not result in the optimum rate of exploration effort and resource development for all areas, particularly for higher risk ventures or areas thought to be less promising.

Much of the geothermal exploration effort and information is similar to that for oil and gas. Information gathered from either type of activity can be of considerable value relative to other resources and related environmental factors. Since oil and gas exploration is done by the private sector, there could be a duplication of effort and related environmental impacts if a Federal program covered the same area but from a geothermal approach.

Under a Federal program, Federal lands could remain more available for other simultaneous or sequential compatible uses during exploration and initial development stages. At time of leasing, only those lands required for geothermal production from proved reserve areas would need to be included in leases or permits. If exploration did not result in producible geothermal reserves, the public lands would remain available for other uses as they would not be encumbered by leases. A Federal program could provide for more orderly and environmentally safe development and use of public lands and their resources. Land management plans could be based upon a more complete inventory of all potential resource values and uses. By contrast, private exploration and development could result in geothermal leasing of areas that might subsequently be found to have more important or higher priority uses than might have been identified by Federal exploration, planning, and development.

It is possible that virtually all potential benefits of Government exploration and development could be achieved by other Federal policies, actions, and controls. For example, it could be required that all Federal land geophysical information be made available to the Government. Likewise, public disclosure of such information could be required.

If geothermal exploration and development activities are properly conducted, the environmental impacts for any given area should not be significantly different under Federal or private sector operations. The proposed leasing and operating regulations are so designed as to provide adequate environmental protection throughout all stages of geothermal activities.

Federal operations could be more environmentally sensitive than commercial operations, particularly where environmentally related costs are a major factor. Private sector operators could range from reputable

companies that will make every effort to comply fully with all environmental protection laws, regulations, and stipulations to individuals who will have little or no regard for environmental values, particularly if protective measures result in additional costs. The various environmental protection controls included in the geothermal regulations such as the exploration notice of intent; bonding requirements; required compliance with Federal and State environmental laws and standards; site-sensitive stipulations; etc. are designed to hold adverse environmental effects to acceptable limits. Surveillance of operations and post-operational inspections can detect potential damage and provide for the necessary corrective measures. However, in some instances there still may be greater adverse impacts from private operations than would occur if the same exploration on the same area had been federally conducted.

Private sector exploration and development, at least in the near future, probably would concentrate on the more promising geothermal areas near population centers as such areas could be more subject to economic development. Such lands probably would be subject to more and heavier existing uses and development than more remote areas. Environmental impacts relative to existing uses could be significant, particularly if conversion to industrial type operations should occur. However, since the lands already are subject to varied degrees of use, the incremental impact might not be as great as would occur from exploration and development in more remote areas where there are no roads or trails for access, or where other uses have not impacted significantly on the natural environment.

b. <u>Joint or coordinated Federal and private sector exploration and development</u>

Exploration and development could be achieved through a joint or coordinated Federal/private sector effort. Such a Federal program could be in the form of a direct Federal effort, federally funded contracts, or Federal contributions to defray a portion of the private sector costs for projects that otherwise might not be undertaken by the private sector because of economic or other constraints. Similarly, provision could be made for private sector financial contributions to Federal programs to reflect appropriate cost sharing relative to the magnitude of potential benefits to be derived. This could result in the better utilization of physical and financial capabilities to assure that public land geothermal resources are explored and developed in the most timely, effective, and environmentally safe manner. Responsibilities and activities could be programmed as follows:

(1) Soon after the leasing regulations are in effect there may be a positive showing of private sector interest as evidenced by notices of exploration intent, leasing applications, and nominations for competitive bid leasing. Reliance could be placed upon the private sector for the exploration and development of areas subject to such interest. The private

sector would assume all responsibilities for such activities consistent with whatever land, natural resource, and environmental protection stipulations as are necessary.

(2) There probably would be many areas of interest to the private sector but for which costs, risks, etc. may be such as to preclude timely exploration and development. It might be appropriate for the Federal Government to share in the costs for exploration and development of such marginal areas or to pay the extra cost for information primarily of value to the Federal Government. If the resource potential is not suited for development, the lands would be subject to other uses without the need for further consideration of potential geothermal development. Valuable resource and environmental information would have been obtained which could be used for overall land and resource management.

(3) Where there is little or no evidence of private sector interest in potential geothermal lands, it might be appropriate for the Federal Government to conduct whatever exploration and development work as is necessary to inventory resource potentials and environmental factors that should be considered in the overall planning of future uses for such lands. In some instances, findings might be such as to be conducive to early private sector development. Lands found to have little or no geothermal potential would be free of geothermal encumbrances and their use could be planned accordingly. This would constitute an integral part of the overall public land management and environmental protection responsibility for information required to assure their most effective development and use in meeting highest priority public needs. The Federal program could be scheduled consistent with energy resource or other public land use priority needs. Such efforts could be limited to geothermal resources or be comprehensive geologic and geophysical investigations which could serve many purposes.

4. Alternative Sources for Electrical Energy

Numerous studies of national energy demand have been made in recent years and all predict a rapidly increasing demand. Three authoritative studies, which will be relied on subsequently in this statement are "United States Energy - A Summary Review" Department of the Interior, January 1972; United States Energy Through the Year 2000, Department of the Interior, December 1972; and "U.S. Energy Outlook," an appraisal made by the National Petroleum Council at the request of the Secretary of the Interior, issued in November 1971. The Department estimates that gross energy input in the United States will increase from 68,989 trillion Btu in 1971 to 191,900 trillion Btu by 2000.

The portion of the total energy demand in the year 2000 attributable to electric generation by utilities is expected to be 76,000-85,000 trillion Btu, depending upon future developments in power generation. Of this energy consumed to produce electricity, some 30,000-36,000 trillion Btu would be available for utilization by the ultimate consumer. The difference in these figures represents inherent efficiency losses in electric power generation, transmission and distribution.

"Mineral Facts and Problems" presents the following discussion of the potential for power generation alternatives:

> "In household, commercial, and industrial heating, and in the generation of steam and (electrical) power, distillate and residual fuels compete with coal and natural gas. A competitor with growing strength in the household heating market is electricity, which is generated from several fuel sources including fuel oil. In industrial and large commercial applications, price frequently is more decisive than it is in domestic or small commercial uses where convenience and related factors outweigh the price advantages of other fuels.
>
> "Air quality regulations are a factor of increasing importance in fuel substitution. Alternative energy sources are being discussed as possible substitutes for air-polluting petroleum fuels in some uses. Such sources include electricity, natural gas and nuclear energy." (The conversion of liquid or gaseous fuel to electrical energy is a consumer of energy because of the inefficiency of the current conversion techniques. Therefore, any increase in electrical generation has the potential for increasing the demand for liquid fuels.)

All forms of energy supplement one another in the total energy picture. Thus, if one kind of energy source material is freed from use in electrical power generation, such as geothermal substituting for natural gas, oil or coal, the material freed is available for use elsewhere, and forces can be set in motion to appropriately adjust resource materials usage throughout the regional or national energy picture.

Primary energy consumption is considered to be energy needed to perform a use without conversions into another energy form. Electrical energy consumption, as discussed below, is here considered secondary consumption since it is the conversion product of another form of energy, i.e., coal, oil, hydropower or radioactive decay. In 1970, nearly half of the power in the electric power generation sector came from the use of coal. About 25 percent came from the use of natural gas and only 10 percent from oil. The remainder came from hydro, nuclear and geothermal plants. If substituted for all the natural gas, there would be a need to allocate 2 1/2 times as much oil as is presently used for the power generation sector. In this same train of thought, if coal were to be replaced by gas, it would require twice as much gas as is presently used or five times as much oil.

The ability of different sources of energy to substitute for each other in power generation is dependent upon cost, plant and equipment design, geographic location and availability of fuel, lead time, and consideration for environment. These variables will be discussed separately to assess the effect of each on the substitution of one energy form for another.

Electric utilities presently consume about 25 percent of the Nation's energy and are projected to increase that share to become the largest consuming sector by 1980. (Dupree and West, 1972—tril. Btu direct energy consumption)

Sector	1971[1]	1975	1980	1985	2000
Household & Commercial	14,281	15,935	17,500	18,960	21,920
Industrial	20,294	22,850	24,840	27,520	39,300
Transportation	16,971	19,070	22,840	27,090	42,610
Electrical Generation	17,443	22,410	29,970	40,390	80,380
Synthetic Gas	-	-	870	2,670	7,690
Total	68,989	80,265	96,020	116,630	191,900

[1] Actual

Cost - Economic considerations are of major importance in considering the ability of one fuel to substitute for another. Although technical feasibility to substitute one fuel for another may exist, costs may prevent substitution. Transportation costs of western low sulfur coal to the East Coast, for example, prevent their substitution for oil and gas in eastern boilers. Although higher costs can be passed on to the consumer, it is possible that rising coal and fuel oil prices eliciting greater supplies would not allow them to replace natural gas if price alone were the only consideration in substitutability. Table IV-3 lists average electric utility fuel costs for years 1968, 1969 and 1970. The variance of the Uranium Costs reflect the nature of present nuclear plant costs since the fuel is continually expending energy, even during plant breakdown or low demand periods.

Plant and Equipment Design - When considering substitutability of energy sources as related to electric power generation for the short-term we currently are confined to substitutions among oil, gas and coal. Development of geothermal resources could have considerable potential, particularly on a local area basis. Nuclear plants require lead times of 10-12 years to build and cannot be converted to burn fossil fuels. Geothermal steam equipment is also specialized, consisting of low pressure turbines unsatisfactory for conversion to some other fuel type. Table IV-4 projects fuel use for thermal power generation until 1990.

TABLE IV-3

AVERAGE ELECTRIC UTILITY FUEL COSTS *

[As Burned]

(Cents per million British thermal units in dollar value in year incurred)

	Nuclear Uranium Costs Per Million Btu, Various Individual Nuclear Plants **	Coal	Gas	Oil
1968	26.04, 28.50	25.5	25.1	32.8
1969	29.35, 34.80	26.6	25.4	31.9
1970	16.54, 23.00, 48.92 14.84, 17.60, 14.84	31.1	27.0	36.6
1971	33.02, 21.10, 19.93, 19.30 18.39, 16.10, 15.77, 15.14, 14.94			

* Fuel and Energy Resources Interior and Insular Affairs Hearings, April 1972.

** Due to a lack of consistent data from all nuclear power plants, periodic core replacements, and high nuclear plant capital costs, these figures are subject to considerable irregularity between different nuclear plants, and the same plants for different years. Data from: FPC Steam Electric Plant Construction Costs and Annual Production Expenses. FPC, S-199, 1968; FPC, S-209, 1969; FPC, S-22, 1970; FPC S-230, 1971.

Note:

From the figures in the tables it appears that, on the average, coal fired plants may be crossing the break-even lines with full pollution control equipment. In many areas of the country they will not be as economic as nuclear plants. Nevertheless, the industry expects many coal plants to be built because of the shorter lead times in comparison to nuclear plants and because there is judged to be insufficient capability to plan, engineer, review, approve and construct significantly more nuclear capacity than is presently projected for 1985.

TABLE IV-4

Projected Distribution of Fuel Use for Thermal Power Generation 1970-1990 1/

[Percent of Heat Input]

Fuel	Year 1970	1980	1990
Coal	54%	41%	30%
Natural gas	29%	14%	8%
Residual fuel oil	15%	14%	9%
Nuclear	2%	31%	53%
Totals	100%	100%	100%

1/ The 1970 National Power Survey, Federal Power Commission, December 1971.

Although nuclear power increasingly will substitute for fossil fuels, short-term substitutability of fuels for power generation is limited to gas, oil and coal. Most boiler fuel power plants can convert from coal to oil with a lead time of six months or more if: (1) the equipment is available; (2) there is room in the plant to install the new equipment; (3) enough Btu's are generated by the fuel substitute to efficiently heat the boiler; (4) adequate resources are available to warrant changing over to handle new fuels; and (5) it is economically feasible.

Many eastern power plants are equipped to burn both oil and coal. For such plants conversion to 100% coal or 100% oil generally involves a matter of 1-2 weeks. Many other plants, however, are designed to run only on coal. For these plants, extensive modifications involving six months to a year are necessary to make the conversions. Table IV-5 illustrates the trend in new generating units to move towards steam electric units with high substitutability of fuels.

TABLE IV-5

Types of New Generating Units as a Percent of Total Annual New Capacity in Contiguous U. S., Excluding West, South, Central and Pacific Regions 1/

	1971	1972	1973	1974	1975
All conventional steam-electric units (coal, oil and gas)	46.1	49.2	49.2	59.2	58.7
(Coal fired only)	38.5	39.5	40.2	39.5	43.6
Nuclear	26.7	31.7	38.6	32.7	35.2
Other (i.e., hydroelectric, geothermal)	27.2	19.1	12.2	8.1	6.1
Total	100.00	100.00	100.00	100.0	100.0

With environmental concerns, the trend has been to use oil instead of the higher sulfur producing coals. Plants designed for all-coal fuels cannot readily convert to use oil or gas.

1/ Steam Electric Power Plant Factor, 1971, National Coal Association, 1972.

During the last week of May, the FPC Staff released a report summarizing by month information collected via Form No. 423 in regard to quantity, cost and quality of fossil fuels delivered to electric utilities in the fourth quarter of 1972. The information was reported by 267 electric utilities for 744 steam-electric plants pursuant to FPC Order No. 453 (R-432), issued 6/7/72, which directed submission of monthly data as to type of purchase, source, quantity, Btu, sulfur content, ash percent and unit cost of fossil fuels received by each electric generating plant with a capacity of 25 megawatts or more under individual contracts. The first reporting month was July 1972. 1/

Comparing data on fossil fuel deliveries in the fourth quarter of 1972 with deliveries in the third quarter of 1972 and with fossil fuel consumption in the fourth quarter of 1971, the report called attention to the following major trends: (1) a significant decline in use of gas; (2) continuation of a rapid increase in deliveries of residual oil; and (3) a sudden large jump of 80% in deliveries of low sulfur residual oil over third quarter deliveries.

The following table sets forth the total quantity and relative proportion of coal, oil and gas delivered to steam-electric plants in the third and fourth quarters of 1973, and quantities consumed during the fourth quarter of 1971.

	Coal		Oil		Gas	
	Quantity (mil/tons) a/	% of Total Btu	Quantity (mil/bbls) b/	% of Total Btu	Quantity (Bcf) c/	% of Total Btu
4th Quarter 1971	79.7	53.6	106.0	19.7	861	26.7
3rd Quarter 1972	90.2	52.1	111.4	17.2	1,174	30.7
4th Quarter 1972	87.7	55.5	128.0	22.2	771	22.3

a/ Includes all types of coal and petroleum coke.
b/ Includes residual oils (#4, #5 and #6), distillate oil and crude oil.
c/ Includes natural gas, refinery gas, blast furnace gas, coke over gas and SNG.

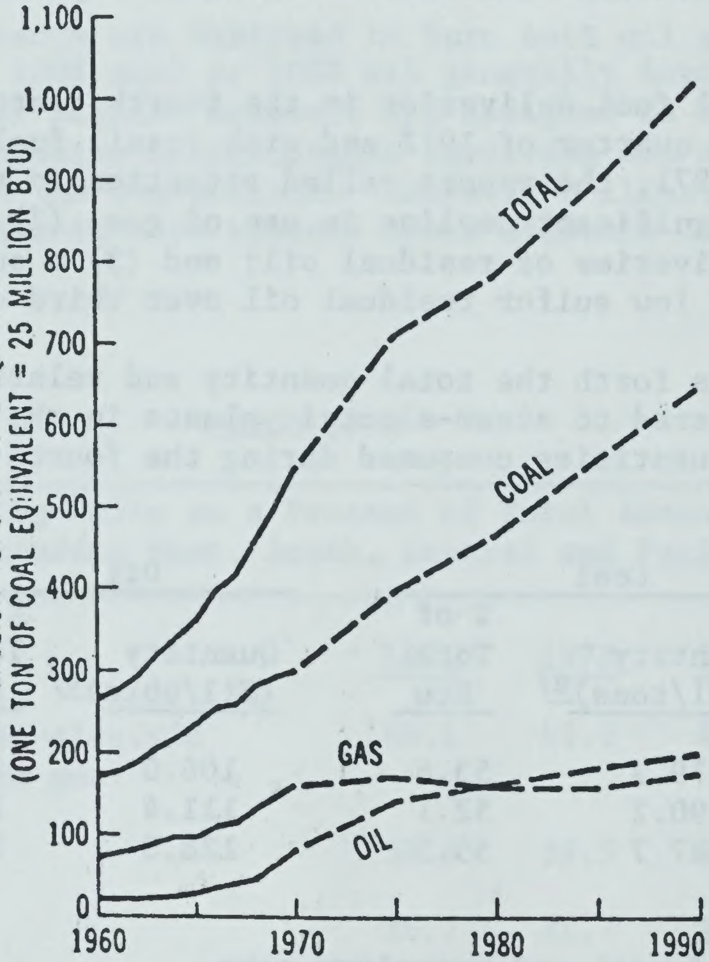
(Source: Foster Associates Report No. 900, July 14, 1973)

1/ In the future, the FPC intends to issue monthly news releases on the Form 423 data, with the first covering July 1972, and others to be released shortly thereafter until they are up-to-date.

Below are Federal Power Commission projections of the total requirements for the three most substitutable fuel sources in electric power generation.

Figure IV-1

ESTIMATED ANNUAL FOSSIL FUEL REQUIREMENTS FOR ELECTRIC UTILITY GENERATION



Geographic Locations and Availability - In some locations one energy source is easily adaptable and more preferable than another. For example, it is not likely that a fossil fuel plant would be built at Geysers, California where geothermal steam has been developed. Availability of low cost coal in "coal competitive" areas often is a function of transportation costs. Table IV-6 illustrates the substitutability of fuels in relation to location and transportation costs. The capacity of a transportation system is rated by its volume capacity; secondly, its capacity to produce 10^{12} Btu in a day (a 10^{12} Btu/day), and finally, transportation costs in cents per million Btu per 100 miles. For example, a 1,000 million standard cubic feet per day (MMscf/d) capacity gas pipeline has a capacity to produce 1.10^{12} Btu per day and would cost 1.5 cents per million Btu over each 100 miles.

TABLE IV-6

COMPARISON OF ENERGY TRANSPORTATION COSTS 1/

	Capacity	Capacity in 10^{12} Btu/Day	Cents/Million Btu/100 Miles
Pipeline - Gas	1,000 - 5,000 MMscf/d	1 - 5	1.5-2
Pipeline - LNG	500 - 1,500 MMscf/d	0.5	1.5-3
Pipeline - Oil	300,000 - 1,200,000 bbls/d	20 - 75	0.3-0.8
Pipeline - Coal	3-15 million tons/yr	0.2 - 1	1.3-3.8
Barge - Coal	900 - 1,400 tons/barge	--	1.2-1.7
Tanker - Oil	100 - 300 thousand DW tons	--	0.5
Rail - Coal	70 - 100 tons per car	--	4-6
Unit Train - Coal	3 million tons/yr	0.2	2.5
Highway - Coal	10 - 20 tons/truckload	--	9-18
Electric	600 - 1,000 MW	0.1	7-14

Substitutions of one form of energy for another by producing power from coal, for example, at mine mouth coal-electric plants and sending the power across the country to substitute for hydroelectric power in New England, is a function of distance which would be subject to high transportation costs. In this example, producing power from a locally cheap and abundant fuel and sending it long distances might not constitute an economic substitute due to high electrical transmission costs. Although direct current transmission is cheaper, it is not yet widely accepted. It involves some efficiency loss in conversion to AC.

1/ The 1970 National Power Survey, Federal Power Commission, December 1971.

Therefore, substitutability would be heavily affected by geographic locations and the nature of fuel sources close enough to allow economic transportation to the point of use.

Lead Time vs. Changeover Time - Lead time and changeover time are important in considerations of whether one energy source can replace another. Fuel substitution in existing plants involves changeover time during which production would cease to exist for a particular unit. Lead time is the time lapse between any initial action to obtain new energy production and the resulting new production. Long changeover times could prevent substitutions if high demand required a power unit to stay in production. Table IV-7 and Table IV-8 list examples of changeover times and lead times projected from the time there is a decision to proceed until production comes on line.

Such conversions are not necessarily reversible. After being idle for long periods of time, deteriorated equipment cannot always be reused. In addition, changing price structures of fuels and environmental considerations such as the amount of sulfur in the fuel add to the difficulties inherent in any decision for changeover in fuels. In 1973, impending oil and gas shortages may be preventing the option of wholesale conversion to these fuels.

Environmental Considerations - Environmental considerations are becoming increasingly important in considering fuel substitutability. As shown in Table IV-9, power plants were responsible for about 12 percent of the estimated nationwide total pollutants in 1968, although they were the largest contributor of sulfur oxides to the air.

TABLE IV-7

CHANGEOVER TIME REQUIREMENTS

Change to		From	Plant	Interrupted time
Boiler Fossil Fuel Plants				
All	Oil	Coal	coal-oil plant	1 - 2 weeks
All	Coal	Oil	coal-oil plant	1 - 2 weeks
All	Oil	Coal	all coal plant	6 mo. - 1 yr.
All	Coal	Oil	all oil plant	6 mo. - 1 yr.
All	Gas	Coal	coal-oil plant	1 - 6 mo.
All	Gas	Coal	all coal plant	6 mo. - 1 yr.
Non-Boiler Fuel Plants				
Coal		Gas	Gas-diesel combustion turbine plants	No conversions

TABLE IV-8

LEAD TIME REQUIREMENTS

New Construction of	Time
Boiler Fossil Fuel Plants	5 - 6 yrs.
Gas-Diesel Turbine Plants	4 - 6 yrs.
Nuclear Plants	10 - 12 yrs.
Pump Storage Hydro Load Leveler Plants	5 - 6 yrs.

TABLE IV-9

Estimated Nationwide Discharges of Airborne Pollutants 1968 1/

(Million tons per year)

	Carbon Monoxide	Part. Matter	Sulfur Oxides	Hydro-Carbons	Nitrogen Oxides	Total
Power plants	0.1	5.6	16.8	Neg.	4.0	26.5
Other fuel combustion in stationary sources	1.8	3.3	7.6	0.7	6.0	19.4
Transportation	63.8	1.2	0.8	16.6	8.1	90.5
Industrial processes	9.7	7.5	7.3	4.6	0.2	29.3
Solid waste disposal	7.9	1.1	0.1	1.6	0.6	11.2
Miscellaneous	16.9	9.6	0.6	8.5	1.7	37.3
Totals	100.2	28.3	33.2	32.0	20.6	214.2

1/ National Air pollution Control Administration (now Air Pollution Control Office, Environmental Protection Agency).

Note: Sulfur oxides expressed as tons of sulfur dioxide and nitrogen oxides as tons of nitrogen dioxide.

New environmental legislation to limit power plant intake fuel to 0.7 percent sulfur would greatly reduce eastern air pollution, but many plants now using 2.5 percent sulfur fuel would be forced to make substitutions to a lower sulfur fuel, if available, or in some cases abandon operations entirely. Mine mouth plants in remote eastern areas are an example, since they are faced with the geographic dilemma of high transportation costs as a result of transmission distance, diminishing supplies of oil and gas at increasing prices and a changeover time to six months to a year to make a conversion.

The fuel requirements shown in Figure IV-1 can also be correlated with projected future distributions in generating capacity, shown in Table IV-10 which demonstrate the percent contribution to the total energy capacity of various energy sources up to the year 1990.

Since substitutability for practical short-term purposes generally is limited to fossil fuels in the power producing sector (presently accounting for over 70 percent of generation capacity) it deserves attention in the study of the energy problem. Geothermal resource development could offer an additional source for electrical energy generation in the western states.

Power Concentration in Western States - The 1970 energy consumption by electric utilities within PAD District V 1/ is estimated to be 2,705 trillion Btu (NPC,1971) of which roughly 800 trillion Btu will reappear for electrical distribution. This is expected to grow to 5,477 trillion Btu consumption by electric utilities by 1980, of which some 1,600 trillion Btu would reappear for electrical distribution. When the projected 1,000 to 2,000 MW capacity of The Geysers field is expressed in Btu (27 to 54 trillion Btu), it can be seen that as of 1980, geothermal generation will comprise only 1.7 to 3.4 percent of the total regional needs for PAD District V.

Forecasting the potential for geothermal power development is uncertain at best because such development depends largely on unknown factors, principally those concerning the availability and extent of geothermal reservoirs, the cost of winning steam and generating power from hot water systems, and the future costs of competing methods of generating power. Accordingly, in order to put the alternatives in proper perspective, this report will consider three rather subjective levels of geothermal capacity for the electric-power market: (1) a present capacity of 298 megawatts (MW) all located on non-Federal lands in The Geysers field in Sonoma and Lake Counties, California; (2) a probable ultimate development in The Geysers area ranging from 1,000 to 2,000 MW depending upon future exploration results and involving mainly private land, but including about 10 to 15 percent Federal ownership (similar potentials in the 1,000 to 2,000 MW

1/ Petroleum Administration for Defense District V comprises the states of Arizona, California, Nevada, Oregon, Washington, Alaska and Hawaii.

TABLE IV-10

FUTURE DISTRIBUTIONS IN GENERATING CAPACITY 1/

Type	In Service End 1970	1970-1980 Additions During Period	1970-1980 In Service End 1980	1980-1990 Additions During Period	In Service 1990
	Percent of Total Capacity 2/				
Hydraulic					
Hydroelectric	15	5	10	2	7
Pumped storage	1	7	4	7	6
Sub-totals (rounded)	16%	11%	14%	9%	12%
Thermal					
Steam-electric					
Fossil-fuel-fired	77	45	59	34	44
Nuclear	2	40	22	53	40
Gas turbine & diesel	6	3	5	3	4
Sub-totals (rounded)	84%	89%	86%	91%	88%
Total	100%	100%	100%	100%	100%

1/ The 1970 National Power Survey, Federal Power Commission, December, 1971.

2/ Since different types of plants are operated at different capacity factors, this capacity breakdown is not directly representative of share of kilowatt-hour production. For example, since nuclear plants are customarily used in base-load service and therefore operate at comparatively high capacity factors, nuclear power's contribution to total electricity production would be higher than its capacity share.

range may be possible in other areas, such as the Mono Lake-Long Valley area, so this is a representative capacity relative to other power generation sources for consideration of alternatives); and (3) the development of 7,000 to 20,000 MW capacity by 1985, as recently projected by the New Energy Forms Task Group of the National Petroleum Council Committee on U.S. Energy Outlook (National Petroleum Council, 1972). The 7,000 MW projection by the National Petroleum Council assumes present steam turbine technology, whereas the 20,000 MW projection assumes development of a dual fluid exchange system utilizing a low boiling point fluid such as freon or isobutane to drive the turbine.

Examination of the potential for geothermal development on the public lands (Godwin and others, 1971) indicates that such potential is limited generally to the western states. Furthermore, commercial interest in development is largely restricted to California and Nevada, and to Oregon and Washington to a lesser degree. Thus, the role of geothermal development in helping to meet national energy needs and its relationship to alternative means of supplying energy is discussed primarily in the context of the West Region as defined by the Federal Power Commission, which includes the areas of Federal lands. 1/ Table IV-11 presents projections of electric power demand and fuel use in the West Region for several periods through 1990.

Consideration of alternatives to the three levels of generating capacity described above indicates the following: If the present 298 MW capacity at The Geysers field were removed from the Pacific Gas and Electric system, the company would be obliged to replace this with comparable generating capacity of a different form. Under present economic constraints, this would require increasing capacity by 298 MW at existing plants by decreasing reserve capacity, or by providing new generating capacity in that amount, probably by an addition to existing facilities. Such additional capacity would most likely take the form of coal or oil and gas fueled steam generation. The location and specific environmental impact of the substitute generating capacity are indeterminate as they would depend upon management decisions by private companies which will not have to be made since The Geysers fields are in production.

If the estimated level of 1,000 to 2,000 MW is not achieved by development at The Geysers field, the Pacific Gas and Electric Company would be obliged to generate the equivalent power by other means. This level of power generation would most likely require new construction of oil-fired or nuclear generating capacity (one or two plants). With either source, capacity in the range of 1,000 to 2,000 MW could be provided at a single plant with accompanying environmental impact. As in the previous case, the location of, and the specific type and severity of, environmental impact are indeterminate, depending upon future management decisions.

1/ The states of California, Oregon, Washington, Nevada, Idaho, Utah, Colorado, Arizona, New Mexico, and parts of Texas, Oklahoma, Kansas, Nebraska, Wyoming and Montana; essentially the Mountain and Pacific states.

Table IV-11

SUMMARY OF 1968 WEST REGION SURVEY OF FUELS FOR ELECTRIC GENERATION-NATIONAL POWER SURVEY 1/

		1965		1970		1980		1990	
		Quantity	% of Total	Quantity	% of Total	Quantity	% of Total	Quantity	% of Total
1.	Population (Thousands)	31,006	-	34,650	-	43,400	-	54,241	-
2.	Total Energy Use 10^{12} Btu)	8,904	100	10,721	100	15,585	100	22,608	100
	% Consumed for Electric Generation	-	25	-	29	-	39	-	52
	% Consumed for Thermal Electric Generation	-	11	-	14	-	28	-	43
3.	Total Electric Utility Generation (10^9kwh)	209	100	308	100	631	100	1,205	100
	Thermal Electric Utility Generation (10^9kwh)	89	43	149	48	447	71	1,007	84
4.	Fuel Use for Thermal Electric Utility Generation (Equivalent Trillion Btu's)	924	100	1,469	100	4,228	100	9,767	100
	(a) Coal (Thousand short tons)	7,729	14	15,496	20	59,264	28	93,536	21
	(b) Natural Gas (Billion Cubic Feet)	628	72	855	63	685	17	724	8
	(c) Uranium (Short tons U_3O_8)	14	1	1,027	5	8,175	47	15,640	67
	(d) Thorium (Short tons ThO_2)	-	-	-	-	3	-	100	1
	(e) Oil, No. 6 (Thousand bbl.)	18,555	13	7,705	4	1,400	-	1,425	-
	(f) Oil, Low Sulfur (Thousand bbl.)	-	-	16,000	8	49,375	8	46,000	3
5.	Average Heat Rate, Fossil Fueled Thermal Electric Generation (Btu/kwh)	10,412	-	9,865	-	9,471	-	9,718	-
6.	Fuel Price Estimates (¢/M^2Btu), excluding Transmission								
	(a) Coal	16		15		16		17	
	(b) Natural Gas	30		31		34		36	
	(c) Uranium	26		20		15		13	
	(d) Thorium	-		20		15		13	
	(e) Oil, No. 6	32		32		28		32	
	(f) Oil, Low Sulfur	-		41		42		44	
7.	Fuel Reserves								
	(a) Coal (Million Short Tons, 1968)		263,230						
	(b) Natural Gas (Billion Cubic Feet., 1966)		30,464						
	(c) Uranium (Short Tons U_3O^8, 1968)		148,000						
	(d) Thorium (Short Tons ThO_2, 1968)		100,000						
	(e) Oil, No. 6 (Million bbl., 1966) (15% of Crude & Shale Oil Reserves		101,026						
	(f) Low Sulfur Oil (Million bbl.)		-						

1/ From "The future of Power in the West Region, 1970-1980-1990" West Regional Advisory Committee Report to the Federal Power Commission 1969.

The higher estimate of 7,000 to 20,000 MW capacity envisioned for ultimate geothermal development entails a larger area and additional options for consideration. The West Region, where the principal geothermal development is expected, includes the Lower Colorado River basin, which is the site of several large coal-fired steam electric plants. Several of the existing plants and projected new plants feed power into the power network that serves southern California and have interties to other parts of the west that are considered likely sites for geothermal power development and marketing. Thus, at this level of development, coal-fired steam generation is a viable alternative to geothermal power. The same level of generation could be met by construction of additional oil-fired or nuclear plants closer to the power markets involved. In any event, the 7,000 to 20,000 MW capacity is well within estimated growth of electric demand in the West Region through 1990 and, if geothermal development is not realized, the equivalent requirement will have to be met by other forms of power generation. New plants under construction, particularly coal and nuclear, commonly are designed for about 2,000 MW capacity, so 4 to 10 such plants could be substituted for the estimated 7,000 to 20,000 MW potential geothermal development.

The following sections discuss the various energy sources which could substitute for geothermal power and their potential environmental impacts with particular reference to the West Region. The discussions primarily focus on electric power generation alternatives since this is the form of major geothermal use anticipated at this time in terms of resource location relative to use centers, technology and economic feasibility. Geothermal resources also have the potential for use for heating and air conditioning of buildings and other uses which otherwise would require electrical energy derived from other sources such as fossil or nuclear fuels, or the direct use of natural gas, oil or coal. However, the potential for such uses within the near future is restricted, primarily because of limitations associated with economically moving large volumes of steam or hot liquids over long distances and the physical facilities required for their use. In the event that significant applications of this nature should materialize, they could offset a like amount of energy from other sources. If this were electrical energy, the environmental impacts would be similar to those reflected herein. If they offset other energy forms, the environmental impacts would be those associated with the production and use of comparable energy values.

Additional analysis and discussion of electrical energy alternatives is provided in the Council of Environmental Quality's August 1973 report Energy and the Environment, Electric Power. This report considers the elements underlying the growing demand for energy and the environmental implications of the complex energy systems needed for meeting demand. It analyzes each energy system's efficiency, costs, and environmental impacts as a totality and for projecting the impacts of various mixes of these systems.

a. Coal

Coal is the Nation's most abundant fossil fuel, representing 94 percent of "identified" recoverable primary energy resources, as compared to 3 percent each for natural gas (dry) and oil (including natural gas liquids) (Averitt, 1969). Coal underlies 458,600 square miles in 37 states. Of the remaining coal resources, estimated as of January 1, 1967, to total more than 3,200 billion short tons, over 2,800 billion tons are at depths of less than 3,000 feet, of which over 1,500 billion tons have been identified by mapping and exploration , with 1,600 billion tons estimated to be at less than 1,000 feet below the surface (Interior, 1972). About 390 billion short tons are commercially recoverable under present economic conditions and mining technology.

Currently, coal provides about 20 percent of the total U.S. energy consumption, down very markedly from earlier years when it provided most (78 percent in 1920) of the Nation's energy. Its largest market is power generation which accounts for 61 percent of the total U.S. coal production of about 610 million short tons in 1970. Coal for coke production consumes about 18 percent and the balance, exceeding 100 million tons, is used for manufacturing, general commercial purposes and space heating - markets that have been declining steadily in recent years.

Many important technologic, economic and social factors will influence coal's future capabilities. Among these are the adequacy of mining capacity, to which new additions have been discouraged by uncertainties as to the timing and extent of increased nuclear power generation and of utility commitments thereto; oil imports; and environmental problems, including air and water pollution, land reclamation and uncertainties as to legislative curtailments of strip mining. Other important considerations include more stringent health and safety regulations that have resulted in a reduction in the number of underground mines, a loss in mine productivity, increased costs at underground mines in order to provide an acceptable working environment; and increases in the number and production of surface mines. In addition, mechanization in mining already has reached such high levels (97 percent of underground production mechanically loaded in 1970, 40.5 percent of total production mined by stripping, and 3.3 percent by auger mining) that further major advances in mechanization are unlikely.

The expanded use of coal power generation could be a viable alternative to the development of geothermal resource. Major limiting considerations are those associated with the extent to which it can substitute for other energy sources and the solving of problems associated with the meeting of air quality standards. The latter would be of minor significance in the West where most coals are of low sulfur content.

The sulfur content of U.S. coals ranges from 0.5 to over 7 percent. About 65 percent contain 1.0 percent or less, most of which are found in the western states, far removed from the area of the current major demand and use (The Midwest and the East).

Most current production is in states east of the Mississippi River, where only 20 percent of the reserves (including 100 billion tons of bituminous coal) contain 1.0 percent or less sulfur, while 43 percent contain more than 3.0 percent sulfur. Sulfur oxides are emitted to the atmosphere in direct proportion to the sulfur content of the coal feedstock.

Recent environmental regulations applicable to new electric generating facilities restrict the emission of sulfur dioxide to 1.2 pounds per million Btu of fuel as fired; for bituminous coal, this is equivalent to about 0.7 percent sulfur. It is necessary, therefore, to reduce the sulfur content of the coal prior to burning or to remove sulfur oxides from stack gases following combustion in order that coal may continue to be used for power generation in most areas.

Mechanical cleaning of raw coal is only a partial solution to the problem, since only a small fraction of high sulphur coals can be cleaned sufficiently to meet sulfur standards. Mechanical cleaning affects only pyritic sulfur and leaves untouched the 40 to 60 percent of the sulfur that is bound in the organic structure of the coal. In addition, freeing the small particles in which pyrites occur requires fine grinding prior to cleaning, which in turn adversely affects the cleaning efficiency and restricts the methods of cleaning that can be applied. Tests of some 322 coals representing most of the steam coals produced in eastern United States showed that, under optimum conditions and present technology, less than 20 percent of these coals could be cleaned to 0.7 percent sulfur prior to combustion (Bureau of Mines).

The status of technology for abatement and control of sulfur oxides in combustion gas was recently reviewed by the National Academy of Engineers, National Research Council, whose report concluded that in early 1970 "...commercially proven technology for control of sulfur oxides from combustion processes does not exist." A number of systems are either being installed or operated at the present time on commercial plants, however, to determine the operational and economic feasibilities of the processes.

An abundant supply of low-sulfur bituminous and sub-bituminous coal and lignite occurring in the West Region could be a substitutable alternative for geothermal energy. Much of the coal resources lie in, or adjacent to, the

West Region and could serve as a source for electrical energy production for this area, either by transportation of the coal to powerplants or by transmission of electrical energy from mine-mouth powerplants.

Reserves of low-sulfur coal in the Rocky Mountain States were estimated to be 874 billion short tons as of January 1967 (Averitt, 1969, p. 33); 188 billion short tons are in beds usually 10 or more feet thick and less than 1,000 feet below the surface. The recoverable resources are about 444 billion short tons to a depth of 3,000 feet, with 94 billion short tons situated at depths of 1,000 feet or less. Approximately 45 billion short tons of the recoverable resources could be extracted by open pit mining methods. At present, a very large open pit coal mine may produce 5 million short tons of coal per year. Very large underground mines may produce 2 million short tons per year per mine.

If coal were to be used as a substitute for geothermal energy in the generation of electric power, it is estimated that an additional 1,000 tons of coal per day would be required to replace each 100 MW of geothermal generating capacity. The existing 298 MW Geysers generating capacity would be equivalent to approximately 3,000 tons of coal per day. An equivalent production level could be reached by expanding existing coal-fired powerplants in the West Region. An estimated 10,000 to 21,000 tons of coal per day would be required to replace the 1,000 or 2,000 MW power potential of The Geysers and an estimated 72,000 to 206,000 tons of coal per day would be required to replace the estimated ultimate geothermal potential of 7,000 to 20,000 MW. The replacement impact of coal-fired power plants would thus range from a modest scale-up of existing facilities to the development of 35 to 40 large underground coal mines or 15 very large surface coal mines or a combination of both types of mining. Associated powerplants to convert up to 75 million tons of coal per year to electrical energy necessary to meet the 20,000 MW geothermal potential also would have to be constructed. Coal production of this magnitude could have a significant impact on the environment. For example, if such volumes were to be produced by surface mining methods, the estimated areas that would be disturbed annually at alternative geothermal power level could be:

Coal Bed Thickness (ft.)	Millions of Tons of Coal Available Per Sq. Mile @ 80% Recovery (1800 ton/acre ft.)	Annual Areas Disturbed (Acres)			
		1,000 MW	2,000 MW	7,000 MW	20,000 MW
10	9.2	256	525	1,811	5,216
20	18.4	128	262	902	2,611
30	27.6	83	173	602	1,741
40	36.1	64	134	461	1,331
50	46.1	51	102	358	1,043

In addition to the environmental impacts of coal production, there are the health and safety considerations relating to underground and surface coal miners. During 1971, there were 149 fatal accidents in the Nation's underground coal mines and 25 fatal accidents in surface coal mines. Although surface mining has less impact on the health and safety of the mine workers, surface mining may result in a greater environmental impact than underground mining. Possible trade-off between health and safety considerations and environmental impacts must be carefully weighed in determining whether surface or underground mining is more or less desirable.

It is not possible to define all of the environmental impacts that increased coal production may have without specific site locations and information on the interactions between powerplants, air and water quality; however it is possible to point out the general environmental considerations of increased coal production and utilization.

(1) Underground Mining

Subsidence of the ground surface is common above many abandoned and some active coal mines. The amount of subsidence relates to the mining method employed, the amount of coal removed, the thickness of the coal bed, and the composition and strength of rocks overlying the coal. Subsidence of large areas may destroy manmade structures, disrupt the ground water flow regime, cut off surface and sub-surface water recharge, adversely affect the quality of underground and surface waters, redirect the planned drainage of a mine, disrupt surface drainage, and in periods of heavy rainfall localize flooding. It also causes landslides and minor earthquakes in some localities.

If a room and pillar mining system is used, the most successful method of preventing or alleviating surface subsidence problems is to plan mining so that more pillars are left untouched. Unfortunately, this procedure results in less coal recovery. Much additional research is needed to develop methods of underground mining which will minimize subsidence of the surface.

Ground and surface waters entering active underground mine workings are normally pumped to the surface for disposal. Because of the low sulfur content of most western coals, it is uncertain whether acid-mine water would be a problem in areas of large-scale mining having an above-average annual precipitation. If acid-mine water problems should develop, it is likely that the modern treatment methods employed in the coal fields of the eastern United States could be implemented to abate acid water impacts. The large volumes of sludge resulting from such treatment could be emplaced either in abandoned mine workings or in protected surface mine waste disposal areas. Commonly, acid-mine water drains from abandoned mines and workings. This type of effluent discharge can be prevented by locating mine entries at elevations above the prevailing drainage level by sealing abandoned underground entries and by emplacing dams at critical points in abandoned underground entries and haulageways.

In most coal producing areas, mining and processing wastes contribute large volumes of sediment to nearby streams, are sources of acid drainage and, where waste piles are burning, are sources of air pollution. The most commonly used technique of preventing widespread scattering of mining and processing wastes is to compact the waste in layers, seal it with incombustible soil, and establish vegetation to prevent infiltration of surface water and minimize erosion.

An alternative to surface disposal of mine and coal processing waste is to return it to abandoned underground mine workings. This is currently being done to control surface subsidence in mined areas in the Eastern States in compliance with restoration provisions of the Appalachian Regional Development Act of 1965, as amended. (Kenahan and Flint, Bu. Mines I.C. 8529, p. 24)

Dust from mine access roads, coal handling, and processing can be alleviated. Road dust can be minimized by hard surfacing, or through abatement techniques, such as oiling or chemical treatment of the road surface. Dust from coal handling and processing can be abated by spray treatment at transfer points and by enclosing coal handling and processing structures. Dusting problems in live coal storage piles can be reduced by water sprays or oiling; dead storage piles can be sealed with asphaltic or chemical materials.

Underground mining results in less noticeable noise and vibration than surface mining, and the surface environmental effects from drilling, blasting, and spills and leaks are minimal. Also modifications of the habitat and alteration of ground cover and surface drainage systems would occur only in a limited sense.

Most pollution sources can be eliminated by sealing and revegetating waste disposal areas; sealing abandoned mine openings; dismantling and removing abandoned mine buildings and structures; and scoring, fertilizing, and revegetating areas formerly occupied by buildings and structures, mine roads, and supply storage areas. Consideration should also be given to flushing all wastes and plant refuse into underground mine voids to remove sources of surface pollutants and to reduce possible surface subsidence. Such flushing of wastes could have either beneficial or detrimental effects on the ground water flow and surface drainage, depending upon local conditions.

(2) <u>Surface Mining</u>

Open pit mining disturbs considerably more surface acreage than underground mining. Underground mining operations, however, because of lower recovery per unit of area, actually disturb more acreage in

three dimensions than an open pit mine producing a similar tonnage. The full magnitude of underground disturbances generally are not understood by the public. As of 1967, it is reported that open pit coal mines were responsible for 41 percent of the land disturbed by surface mining in the United States (U.S. Department of the Interior, 1967, p. 53-54).

Climatic conditions are extremely important in considering the rehabilitation, reseeding and revegetation of mined lands. Obviously, without proper moisture, the reseeding of reclaimed lands would serve little purpose and erosion processes would soon destroy the contour of the rehabilitated lands.

Disruption of the land surface by open pit mining would, unless proper precautionary measures are implemented, have adverse impacts on all vegetation, forestry, grazing, crops, birds, land animals, endangered species, habitat, water supplies, and water quality. These impacts would limit the enjoyment of hunting, fishing, and allied leisure time activities in addition to affecting scenic vistas and open spaces. Furthermore, nearby agricultural, residential, commercial, and industrial activities may be affected by adverse environmental impacts propagated beyond the area of mining.

Few coal deposits are free of contaminants. Therefore, it can be assumed that under ideal conditions a 5-percent washer loss would occur. The problem would not be major for surface mines in that the pits from which the coal would be extracted could receive this material. Ultimately, the mine pits would be backfilled, the spoil banks topped off or leveled, the highwalls backsloped, the top soil replaced, and the area reseeded.

Other short-term problems related to surface coal mining are acid mine water developing in the open pits, in spoil piles, and in mine processing waste; silt eroding from the pits, processing waste and spoil piles; and dust blowing from the pits, spoil piles, truck haulage roads, railroad cars, mine processing plants, and processing waste piles. Each of these problems can be handled effectively by requiring the mining companies to observe environmental regulations.

Proper supervision within the scope of adequate environmental regulations could result in mined lands being returned to as good or better than found conditions, in that some restored lands could lend themselves to recreational sites, lake impoundments for boating and fishing, picnic areas, and eventually could promote resort facilities.

The end use to which surface-mined lands can be reclaimed concurrent with mining is limited only by the capacities of men operating within prevailing geologic, technologic, and economic restraints.

(3) Mine Mouth Powerplants

A recent development at several of the western coal mines is the establishment of the powerplant at the mine mouth. The adjacent development of mine and powerplant greatly reduces the cost and environmental impact of any coal transportation system and allows ash from the powerplant to be readily returned to the mine for disposal. Burial of the ash between the spoil banks and in the pit cuts at surface mines reduces the possibility of water or wind transport of the ash and subsequent environmental damage. Mine mouth powerplants associated with underground mines require surface disposal areas for the ash. Transmission lines from the mine mouth plants may have an impact on the environment, depending upon routings and the availability of existing transmission lines with reserve capability for handling the additional plant output.

Location of the powerplant at the mine mouth depends upon several critical factors. Water for cooling purposes must be available in sufficient quantities at the plant site or within a reasonable distance of the powerplant to allow economical pumping operations to bring the water to the plant. Pipeline routings to bring water to the powerplant can have an environmental impact which must be considered during the planning stages. The coal supply at the mine must be of sufficient quality and quantity to supply the powerplant over its projected operating life. Insufficient coal supplies will require coal to be shipped to the powerplant if the local supplies are exhausted at an earlier date than expected. Environmental considerations relating to transmission line routings, plant siting, combustion byproducts, water usage, surface storage of ash at underground mines and other such factors must be favorable to allow development.

(4) Coal Transportation

Four systems could be used for moving coal from a mine to a point of utilization. These systems are trucks, railroads, conveyors and coal slurry pipelines. A fifth system, water transportation, may be discounted because of the lack of navigable waterways. Each system has advantages that would make it economically attractive for transporting coal to a point of utilization. Selection of a system would be strongly influenced by the distance to a utilization plant.

The major adverse environmental impacts of these transportation systems are air and noise pollution, safety, the amount of land required for rights-of-way, waste disposal and water quality and aesthetics.

Air pollution sources are exhaust emissions, road dust, and coal dust. The level of adverse exhaust emissions can be reduced through efficient engine maintenance; road dust can be reduced by haul-road surface treatment, such as hard surfacing, oiling, or applying water-chemical solutions; and coal dust can be reduced by truck covers and spraying. Although mufflers can

reduce the level of noise pollution, truck haulage, because of the large number of noise sources and frequent trips, is commongly recognized as the noisiest system of transportation.

Collisions between trucks, other vehicles and animals can occur but do not normally constitute a serious public hazard because haulage roads generally are confined to mine property.

Land use committed to truck haulage is the largest of any of the coal transportation systems. The presence and movement of large numbers of trucks in open areas may be aesthetically objectionable to the public, especially if the haulage roads are near public use areas.

Secondary environmental impacts from truck transportation arise from improper disposal of tires, expended oil and used parts. These items can be disposed of in open cuts of surface mines and then buried with reclaimed spoil and revegetated. In addition, special disposal pits can be excavated at underground mining operations where these items can be buried and the area revegetated. Depending on the economics of a particular mining operation, a reasonable alternative would be to recycle these items.

Rail transporation systems using diesel locomotives are sources of air and noise pollutants from engine exhaust systems. Effective maintenance of engine combustion systems and efficient mufflers can reduce the air and noise pollution levels from these systems. Coal dust lost in transit can be reduced by using partially covered hoppers or by oiling the coal during loading. Dusting during loading and unloading can be reduced with a combination of dust suppression sprays and enclosed chutes or bins.

The right-of-way for a railroad constitutes a permanent commitment of the land surface to this use, making it unavailable for other uses. Free travel of vehicles, people and animals across the committed area is restricted; however, the potential for collisions with trains does exist.

In open or scenic areas, railroad rights-of-way may be considered as aesthetic intrusions, especially if large trestles. overpasses, or cut and fill areas are required. Cut and fill areas can be constructed with gentle slopes and revegetated, and borrow areas can be reclaimed as mentioned in conjunction with truck transportation systems. The visual impact of trestles, overpasses, and other appurtenant structures can be minimized with effective combinations of eye-pleasing designs and unobtrusive colors.

Conveyor system installations likewise constitute a permanent commitment of the land surface and restrict free movement of vehicles, people and animals. The right-of-way width is less than that required for truck or railroad transportation systems. Uncovered or partly covered conveyors

allow loss of dust in transit because of exposure to winds. Uncovered transfer points also are a potential source of dust when suppression devices are not provided. Open, or partly covered, conveyors constitute a safety hazard to persons or animals when a support structure is installed close to the ground. Conveyor systems can be fenced or completely enclosed to eliminate dusting and safety hazards to humans and animals.

Conveyor support structures, either frame or suspension type, as well as the conveyors, are obvious visual intrusions, especially at points where the conveyor crosses deep drainage systems. Color treatment and aesthetic design of support structures, enclosures, and transfer structures would lessen this impact.

The principal impacts of coal slurry pipeline systems are the permanent commitment of land, providing an adequate water supply and waste water disposal. Large quantities of water, at the rate of one ton of water per ton of coal, are required to transport coal in the Black Mesa, Arizona, Pipeline (Arnold, 1969, p. 8). In water deficient areas, this method may not be an efficient transportation alternative, particularly where the water must be supplied by deep wells which, when pumped, could have a draw-down effect on shallower wells that supply people or livestock. Additionally, water disposal problems at the terminus of a pipeline could have an impact on water quality if not properly contained or when it is not economically feasible to recycle the water for transporation purposes. Coal slurry destined for power, gasification, or liquefaction plants could be dewatered with the "spent" water used for cooling tower makeup, ash handling and/or evaporated in disposal ponds. The Mohave generating station in Nevada is utilizing water from the Black Mesa Pipeline in this manner.

The disposal of solids and water removed from sections of a plugged pipeline could cause environmental impacts. Holding ponds, equal in capacity to the upstream pipeline, could be provided at pumping stations and at the coal slurry preparation plant for disposal of removed plugs. The water could be evaporated and the coal may be left in the impoundment unless provisions are made for recovery. Compaction and sealing can prevent spontaneous ignition or erosion of the coal left in impoundments. The surface of the impoundment can be revegetated with indigenous or non-native plants to inhibit erosion of the seal.

(5) Waste Disposal

Large volumes of waste are generated during coal mining and processing. The volume of mine waste depends on the type of characteristics of top and bottom strata, the continuity of a coal bed, the existence of fault zones, and the tonnage of country rock that must be mined. The type and volume of waste discarded during coal processing depends upon the specifications for which the coal is being prepared, characteristics and amounts of impurities in the coal bed being mined and the efficiency and type of coal processing equipment.

Uncontrolled disposal of coal mining and processing wastes, especially those containing carbon and trace amounts of sulfur, constitute a source of land, water and air pollutants.

Water flowing over waste disposal areas commonly transports silt and leached minerals to adjacent land and surface water drainage areas. In addition, dust-size particles may be transported by winds to contaminate adjacent land and water resources. If a waste pile containing large amounts of carbon ignites, noxious gases enter the atmosphere creating a hazard to plants, animals, people and property (McNay, 1971, p. 8).

Waste disposal areas require a commitment of land resources. Furthermore, if poorly constructed and uncontrolled, these waste areas present an unattractive appearance to viewers.

Slides and slump failures commonly occur where waste is deposited on sloped and where an improper combination of moisture and clay minerals in the topsoil or in the waste act as lubricants. In such unstable conditions, large quantities of waste can move downslope and have adverse effects on land and water resources as well as being safety hazards to plants, animals and people.

Should fine coal cleaning be included in the preparation processes for coals, the discarded fine waste would probably be deposited in slurry impoundments where the water would either be decanted for recycling to the preparation plant or allowed to evaporate. Poorly designed impoundment dikes in the past have permitted percolating leached water to enter downslope surface water drainage areas.

In addition, construction of impoundments on underlying pervious bedrock commonly results in infiltration of the ground water table by mineralized water or in percolation of such water through the base of dikes to enter downstream surface water drainage systems where these types of leakage commonly affect aquatic plant and animal life. Proper construction of impoundment dams and treatment of impoundment basins can prevent such occurrences.

Unless measures are taken by coal operators to seal and revegetate both coarse and fine waste upon abandonment of waste disposal areas, many unfavorable impacts can continue for decades. However, use of appropriate treatment methods on the part of coal operators, coupled with effective enforcement of waste disposal regulations promulgated by State and Federal Governments, can minimize such effects on the environment.

There can be beneficial uses of waste materials such as:

The waste rock removed during mining can be utilized in many areas as landfill to provide level sites in deeply dissected terrains. This type of landfill is an effective method for disposal of mine waste when properly compacted, sealed, fertilized, reseeded and revegetated.

The return of mining and processing wastes to underground mine voids would lessen the potential for subsidence.

Processing plant wastes, when properly buried and revegetated at sites chosen according to sound geologic and hydrologic information, would have minimal environmental impacts in the thinly populated areas of the West.

(6) Synthetic Fuels from Coal (also see Natural Gas)

Through hydrogenation processes, it is possible to convert coal to various liquid and gaseous forms as a substitute for natural oil and gas. Considerable research and development has been completed or is now in progress by the Federal Government and by private industry. Certain technologies have been demonstrated as commercially feasible but are not now economically competitive. Much of the work in progress is summarized in Department of the Interior's 1973 coal research report (USDI, Office of Coal Research 1973).

The President, in his Energy Messages of June 4, 1971 and April 18, 1973, and in his budget requests has given special attention to the acceleration of coal gasification. Similar acceleration of coal liquefaction technology development could result in economically feasible conversion processes that could provide an alternative source of oil. However, in view of the critical domestic gas and oil supply situation that is developing, any additional supplies of oil and gas so developed probably would not be available for electric-power generation.

The feasibility of using such processes as an alternative energy source depends upon the rate at which technological systems are developed, tested, and proved to be economically viable so that commercial scale plants could be built. It is possible that such could occur in time to produce substantial amounts of synthetic fuel by 1980-1985.

The environmental impacts of coal mining to provide the raw material for the production of synthetic fuels were discussed previously. However, synthetic fuels may require as much as double the volume of coal for the equivalent liquid or gaseous fuel Btu value. Accordingly, mining impacts could be double those associated with use of coal as a solid fuel. There also could be environmental impacts associated with the operation of the conversion plants. Environmental considerations relating to the transportation and combustion of synthetic fuels are similar to those for natural oil and gas and are discussed in following sections. Because much of the Rocky Mountain coals are low in sulfur and are therefore in demand for power generation, it is doubtful that these coals will be used for the production of synthetic fuels before full development of the higher sulfur eastern coals. The deeply buried western coals may provide raw material for the synthetic production of oil and gas when in-situ conversion processes are developed. This is not expected to occur in the near future and, therefore, this energy source is not presently a viable alternative to geothermal steam production.

b. Oil

The principal geothermal resource areas presently being developed or considered for development could supply increasing amounts of electricity to areas where oil is now used for power generation. Conversely, increased domestic production of oil or increased imports of oil could be used to supply increased power generating energy needs if geothermal resources are not developed.

The average heat in Btu's used to produce 1 kilowatt hour from fossil fueled thermal generating plants in California during 1970 was 9,604 Btu per kwh of electricity generated (Federal Power Commission, 1969). These generating plants use oil or gas, somewhat interchangeably, although natural gas, a cleaner burning fuel, is more widely used in the Los Angeles area as an air pollution control measure. This region is also in the principal area of anticipated geothermal power development.

The future use of low-sulfur fuel oil for power generation on the West Coast is projected to double by 1985 providing a larger than present share of electric power. Oil-fired generating stations tend to be located near heavily populated areas to minimize transportation transmission costs. They may have an adverse effect on air and water quality in such areas because of heavy population concentration. Such plants could be unattractive in scenic areas. The oil-fired generating station produces more air pollutants than natural gas but the air effluents generally could be held to tolerable levels except perhaps in the Los Angeles, California area. If oil were used to replace geothermal powered electricity, there would be an incremental increase in air pollution in the powerplant areas.

Oil could be used as an alternative to development of geothermal resources. If oil were required to provide electric energy should geothermal energy not be available, the approximate amounts of oil shown in Table IV-12 would be necessary to replace the geothermal electric energy predicted at intervals during the next 10 to 15 years.

Table IV-12

Oil requirement needed in Western United States to replace electricity generated by geothermal means should geothermal power be restricted 1/

Year	Geothermal Power 2/	Oil Replacement Million Bbls. Per Year	Oil Replacement Thousand Bbls. Per Day
1973	298 megawatts from The Geysers field, California	4	11
1980	1,000-2,000 megawatts	13-26	37-77
1985	7,000-20,000 megawatts from all Western U.S. sources (assuming new technology can be developed to use hot water)	91-260	250-710

1/ The average crude oil yields about 5.8 million Btu per barrel (42 gallons) and the average low-sulfur fuel oil, a refined product, yields about 6 million Btu per barrel. For this purpose, it is assumed that a low-sulfur crude oil yielding 5.8 million Btu could be used in power generating facilities even though lighter fractions would probably be refined off and used for other purposes.

2/ Predicted geothermal power from National Petroleum Council, U.S. Energy Outlook, v. 2, 1971.

The West Coast currently is subject to a short domestic supply of oil, importing such oil as is needed to augment the amounts produced in the coastal areas. Based upon Bureau of Mines supply/demand projections and allowing for full utilization of Alaska North Slope production, there will be a continuing dependence upon imports:

	Million Barrels Daily		
	1972 (Actual)	1980	1985
Production			
California	1.0	0.9	0.9
Southern Alaska	0.2	0.2	0.1
North Slope		1.5	2.0
Subtotal, within district	1.2	2.6	3.0
Receipts from other districts	0.2	0.1	0.1
Processing gain	0.1	0.1	0.1
Total domestic production	1.5	2.8	3.2
Less exports (other districts and foreign)	-0.1	-0.2	-0.2
Net available PAD-V	1.4	2.6	3.0
Demand	2.2	3.0 to 3.3	3.7 to 4.0
Deficit to be met by imports	0.8	0.4 to 0.7	0.7 to 1.0
Percentage of imports	36%	13 to 21%	19 to 25%

The comparable national supply/demand outlook is:

	1972	1980	1985
Probable demand	16.4	20.8	25.0
U.S. production (exclusive of North Slope)	11.6	10.2	9.2
Synthetic liquids			0.5
Crude oil deficit (without North Slope)		10.6	15.3
North Slope production (via Alaska pipeline)		1.5	2.0
Crude oil deficit, with North Slope	4.8	9.1	13.3
Percentage of imports			
With North Slope		44%	53%
Without North Slope	29%	51%	61%

Delays in construction of the Alaska pipeline would seriously increase the import dependency.

Table IV-13 indicates the sources of supply considered feasible between 1971 and 2000.

In 1971, domestic supply accounted for 74.0 percent of U.S. consumption and imports accounted for 26.0 percent. In the year 2000, if the present trends and policies continue, 16.9 percent of requirements will be met by lower 48 supply, 10.0 percent by Alaskan North Slope oil, and 2.8 percent by synthetic liquids, giving domestically produced oil 29.7 percent of our total market. If additional liquid hydrocarbons are to be available to meet projected consumption, they will come from supplemental supplies.

Between now and 1980, these supplemental supplies must come either in the form of imported oil from foreign sources or incremental production from conventional domestic sources, both onshore and offshore, to the extent that it may be made available through increased discoveries of new reserves. The proportion which each of these sources will contribute is dependent primarily upon governmental policies, environmental restraints, and economic conditions during this period. Beyond 1980, supplemental supplies will come not only from these sources but also from such nonconventional sources as shale oil, tar sands, and coal liquefaction. Development of new technologies will also be a contributing factor to the extent these new energy forms are made available.

Table IV-13

Estimated Petroleum supply schedule, 1971 actual with projections to the year 2000

	1971	1975	1980	1985	2000
Total Supply:					
Million Barrels	5,523	6,340	7,615	9,140	12,985
Million Barrels/Day	15.1	17.4	20.8	25.0	35.5
Trillion Btu	30,492	35,090	42,190	50,700	71,380
Domestic Supply:					
Lower 48 Supply 1/					
Million barrels	4,117	4,000	3,740	3,345	2,200
Million Barrels per day	11.3	11.0	10.2	9.2	6.0
Trillion Btu	22,569	22,130	20,720	18,550	12,090
Alaskan North Slope					
Million Barrels	-----	-----	550	730	1,295
Million Barrels per day	-----	-----	1.5	2.0	3.5
Trillion Btu	-----	-----	3,050	4,050	7,120
Synthetic Liquids					
Million Barrels	-----	-----	-----	180	365
Million Barrels per day	-----	-----	-----	0.5	1.0
Trillion Btu	-----	-----	-----	1,000	2,010
Total Domestic Supply					
Million Barrels	4,117	4,000	4,290	4,255	3,860
Million Barrels per day	11.3	11.0	11.7	11.7	10.5
Trillion Btu	22,569	22,130	23,770	23,600	21,220
Supplemental Supplies 2/					
Million Barrels	3/ 1,406	3/ 2,340	3/ 3,325	4,885	9,125
Million Barrels per day	3.9	6.4	9.1	13.3	25.0
Trillion Btu	7,923	12,960	18,420	27,100	50,160
Percent of Total Supply	26.0	36.9	43.7	53.4	70.3

1/ Includes crude oil and natrual gas liquids.

2/ May be from imports, shale oil, coal liquefaction, etc. See text for discussion.

3/ All imports.

Source: United States Energy Through the Year 2000, USDI, 1972

The three primary potential sources for additional crude oil supplies are: (1) increased onshore production, (2) increased offshore production, and (3) increased crude oil or finished product imports.

(1) Onshore Production - Lower 48 States

This alternative would require increased exploration, development, and production of crude oil (and natural gas) from onshore sources. To be a real alternative, supplies of oil and gas would have to be developed to replace the loss of geothermal potential development in addition to those oil and gas supplies that are projected to be produced from onshore sources for other purposes during the same time frame. Experience indicates that it would be difficult to further expand drilling efforts to provide additional needed supplies, especially when consideration is given to the drilling effort required to offset continuing declines in offshore production. Past discovery rates indicate that the drilling of from 13,000 to 35,000 additional wells might be required to provide oil equivalent supplies of the same potential energy production that ultimately may result from geothermal development. In 1970, less than 30,000 wells were drilled in onshore areas.

Onshore drilling in recent years has continually declined; a major contributor to the decline has been a lack of economic incentive. Additional incentives such as subsidies, price increases and tax benefits could result in increased drilling and development of onshore domestic supplies. The President, in his 1973 Energy Message, asked the Congress to extend the investment credit provisions of the present tax law so that a credit will be provided for all exploratory drilling for new oil and gas fields. This would provide a somewhat higher credit for successful exploratory wells than for unsuccessful ones in order to put an additional premium on results.

With increased incentives, additional exploration, development and production of supplies could be expected, but increases in crude oil supplies from new discoveries probably could not be expected to be forthcoming in significant quantities within three to five years.

The Geological Survey's latest calculations of proved onshore oil and gas reserves and estimated additional recoverable resources are:

U.S. Onshore Oil and Gas Reserves and Resources
(Oil 1/ in billions of barrels; gas in trillions of cubic feet)

	Proved Reserves		Recoverable Resources 2/	
	Oil	Gas	Oil	Gas
Public lands	3.0	14.0	250.0	1,153.0
Non-public lands	38.3	237.6	16.0	61.0
Total	41.3	251.6	266.0	1,214.0

Potential onshore reserves would be adequate to meet projected requirements but past and current drilling efforts have not resulted in discoveries that would have provided adequate increased production. The most favorable geologic provinces already have been developed so exploration success possibilities are reduced. In the late 1940's only 30 wildcat wells were needed to locate a significant new field; the number of wells required had nearly doubled by 1960 and this trend has not reversed.

The importance of finding large fields becomes apparent when it is noted that last year 63 percent of U.S. production was from only 264 giant fields; there are over 35,000 oil fields in the United States.

Development of spare shut-in capacity in the Naval Petroleum Reserve at Elk Hills in Kern County, California, could be a partial alternative. Production has been limited to about 2,000 barrels of oil per day. In 1970 shut-in capacity was estimated to be about 160,000 BPD. At that time, the expenditure of approximately $100 million for drilling, plants and compressors and $50 million for additional transportation facilities could result in increased production to about 350,000 barrels of crude oil per day of production. Congressional approval would be required for any appreciable increase over the current producing rate.

Technological advances permit improved recovery of oil from existing reservoirs, and, in effect, increase the "recoverable reserves" in a producing formation by a process called "secondary recovery." Injecting water into the reservoir to mechanically displace some of the trapped oil is an example. Improved recovery techniques have added about 0.5 percent per year to the expected ultimate recovery.

1/ Includes natural gas liquids

2/ Does not include proved reserves

Ultimate recovery of oil is currently estimated at 31.1 percent of original oil in place. The applicability of recovery techniques depends strongly on the nature of the oil reservoir; the estimated recovery ranges from 13.5 percent in Ohio to 65 percent in District 6 of Texas. With estimated original oil-in-place of 425 billion barrels, an increase of only 1 percent in the average recovery of oil-in-place would yield 4.25 billion barrels, or 2 million barrels per day for 12 years. The historic 0.5 percent per year derived primarily through improved water-flooding techniques, however, appears to be decreasing.

It is also important to note that supply/demand forecasts usually include provision for some improvements in recovery,often explicitly. For example, the National Petroleum Council projects reserve additions of 28.5 billion barrels, or 71 percent of its 1971-1985 totals, from application of secondary and tertiary recovery processes (NPC, Coal Task Group, 1971). Much of the production capacity added in recent years has been obtained through such improvements, and further dramatic increases generally are not anticipated at current costs and price levels. Technologic breakthroughs which could contribute significant additional production will probably come from secondary or tertiary recovery methods other than waterflooding. Miscible and thermal techniques have been proved in the laboratory. Some have shown limited technical but not economical success when applied to the actual reservoir.

Incremental gas production, while possibly substantial, is measured with respect to a base of excess production which is declining under present regulation. Natural gas reservoirs are not amenable to the secondary recovery technology breakthroughs that petroleum reservoirs are.

The environmental impacts associated with substitution of the domestic production of oil for geothermal energy in power production involve exploration and production activities, the transportation of the crude oil, refining, and finally its consumption at the electric powerplant. These impacts depend largely on local considerations, such as the site of oil discovery, distance to refinery, means of transport and location of power stations.

(a) Exploration Development and Production

Many of the activities associated with the exploration and development of oil resources are very similar to those involved in geothermal operations. However, oil activities tend to be more intensive as to surface disturbances and, as such, may be somewhat more of an environmental hazard but still generally are of a temporary nature.

A variety of surveys are carried out by aircraft and surface methods. Small single- and twin-engine aircraft and helicopters conduct visual reconnaissance at altitudes of 100 to 500 feet. Flights above 3,000 feet conduct photographic, geophysical magnetometer and geologic visual reconnaissance surveys.

Surface exploration includes casual use of existing roads and trails (to conduct geochemical and reconnaissance surveys to make stratigraphic, lithologic and structural maps and to take air samples) and intensive use requiring extended physical presence on the land and resulting in significant disturbance to the environment.

Geophysical surveys include use of explosives, thumpers, or vibrators to transmit shock to the ground. Explosive methods involve drilling holes in the ground and detonating explosives in the hole. Thumper and vibrator methods use truck-mounted equipment to pound or vibrate the earth. Access trails may be cleared of soft vegetative cover and loose mineral matèrial so that detectors spaced along the trails can receive as much energy as possible. During preliminary reconnaissance, a few such trails would be cut; more intensive investigation of a promising area could require a network of trails on a 1- to 2-mile grid or closer. The seismic explosive method can damage water wells and irrigation facilities in close proximity to the test area.

Other types of geophysical surveys (to measure temperature and other characteristics) use light-weight equipment which is usually hand-carried with very little if any disturbance due to the survey itself.

Subsurface exploration begins with stratigraphic tests, which are usually shallow (100 to 500 feet), uncased holes designed to determine subsurface structural features and correct seismic data. They are usually drilled with truck-mounted equipment and disturb a relatively small area. Temporary roads and trails constructed for access to the test sites are minimal.

Wildcat wells are drilled to verify the existence of hydrocarbon deposits. To support the drilling rig and other equipment, a heavy-duty but temporary road is built. The wildcat well site is cleared of all vegetation and graded to a flat surface. The area of the site depends on the type and depth of well drilled, equipment used, and the topography, and may cover an acre, more or less. At the well site, a drilling rig, mud pumps and pit, generators, pipe rack and tool house are located on the drill pad. Other facilities, such as water and fuel storage tanks, will be nearby. In remote areas, the drilling company may construct additional support facilities such as a drilling camp and an aircraft landing strip or heliport.

During drilling, a special fluid called "mud" (a mixture of water, clay and mineral additives) is pumped down the drill pipe under controlled pressure. This mud is sometimes mixed and stored in pits dug in the ground. If abandoned, it may form a surface crust but may not harden for years.

"Blowout preventers" are installed as safety devices. Their function is to close off the space between the drill pipe and the casing in a matter of seconds if unexpectedly high pressures are met. They will contain

pressures until normal drilling can be resumed. When the well is ready for production, a system of high-pressure surface valves, called a Christmas tree, is installed on top to control the well flow.

A well requires water for mud, cleaning equipment and cooling engines; a water well may be drilled if no other source is available. A pipeline may be laid several miles and a pump installed at a stream to furnish water.

Discovery of oil or gas leads to testing which requires additional equipment such as separators and storage tanks. In some areas, an operator may be allowed to flare gas for a short period for testing; in others, gas may be released unburned to the atmosphere.

If the wildcat does not discover oil or gas in commercial quantities, the hole will be plugged and the location abandoned. The drilling pad and surrounding area should be cleaned up and restored.

Development differs from the later stages of exploration primarily in the extent and intensity of activities. More detailed seismic work may be required to determine the best location for the first offset or development well sites of a more permanent nature; they are generally more stable in their location and construction methods better planned than those in the exploratory phase. As the field develops, the wells are interconnected with a road and pipeline system which results in destruction of vegetative cover, soil movement, siltation and other surface disturbances.

Many fields go through several development phases; new development wells may be drilled past the known producing horizon in an attempt to find additional productive zones. If a deeper zone is developed within the field area, additional wells may be drilled adjacent to existing producing wells--reducing effective well spacing--or the existing wells and any new development wells may be drilled deeper and completed as "multiple completions."

Production - The production phase involves periodic inspection and repair of operating equipment and facilities. In cases of smaller production capacity, oil will be stored temporarily in tanks and picked up periodically by tank truck. When brines are a principal byproduct of the production operation, corrosion is a particularly important problem. Late stages of production usually involve secondary recovery operations requiring additional pumping or injection equipment.

Abandonment - As production declines, some wells in the field may begin to produce too much water. In some oil fields gas produced becomes excessive and wells are eventually shut in and abandoned. Abandonment of gas wells usually comes when reservoir pressure and rate of gas production become too low. Deregulation and higher prices would tend to delay abandonment of existing gas fields and prolong production in new fields. Some of the gathering system, flow lines, and other buried pipe may be left in place if the cost of removal exceeds salvage value and regulations require removal.

(b) Potential Environmental Impacts

These impacts can be associated with areas where petroleum exploration production already is a common practice or to areas where petroleum extraction is virtually unknown. If the incremental production derives from existing producing wells and if storage and distribution systems are adequate to handle the additional produced fluids, the resulting impact will be minimal. If the extra production comes from extending the limits of producing reservoirs, recompleting wells in the producing reservoir or in other reservoirs which they penetrate at greater or lesser depths, or secondary recovery operations, additional impacts will result. These impacts are associated with drilling and reworking production or injection wells, erecting gathering, storage and distribution systems pipelines as well as any other required operating equipment. Since fossil fuels such as petroleum and natural gas theoretically can be discovered in essentially any area where the earth's subsurface crust is composed, at least in part, of sedimentary rocks, the additional production could result from successful exploration of areas where oil and gas extraction is not common. For this case the resulting environmental impacts could be maximum as entirely new production and transportation systems might be required.

The following impacts relate generally to any area where crude petroleum or natural gas extraction could occur:

Air Quality - The impact of additional petroleum production on air quality stems principally from the emission of particulates into the atmosphere; however, some disturbance results from noise and vibrations.

Engine exhausts from vehicles and stationary engines result in emission of the products of combustion. The impact of such pollution is dependent upon the size of the operation, climatic conditions, topography and localized factors. Noise and vibrations from stationary engines used in drilling and production operations and transporting systems can disturb the natural environment. Air quality in immediate areas could undergo some temporary reduction because of removal of ground cover, dust from vehicle traffic and from occasional equipment failure or blowouts.

Vapor venting from storage tanks and vessels, the planned or accidental burning of petroleum and other chemical products, especially those containing sulfur compounds, could release particulates, volatile and noxious oxides of combustion into the atmosphere, as well as objectionable odors. These emissions generally can be classed as intermittent, infrequent and present in small amounts.

Since production operations result in relatively small amounts of air contaminants, it is unlikely that air quality reductions from such operations associated with increased petroleum or natural gas production would significantly alter biological conditions affecting the growth of flora. However, the feeding and nesting habits of birds and animals, wilderness qualities and hunting could be altered as a result of noise and vibrations

associated with increased operations. After termination of operations, a reversion back to original conditions would be expected.

Water Quality - The construction of roads for access into prospective petroleum producing areas could affect water quality where drainage patterns are disturbed or when erosion is possible. Canal dredging can result in temporarily increased turbidity and sediment suspension.

Entry of foreign substances such as oil, chemicals, brine and waste materials into the water cycle can be a major environmental risk associated with petroleum production operations. Spills or leaks allowing such substances to enter the surface or ground water systems can result from human error and neglect, corrosion of pipelines and container vessels, pipeline breaks from vibrations, earthquakes, landslides, ruptures or mechanical failures, burning pits and open ditches and blowouts. During production, large amounts of salt water are usually produced as oil fields age. Such water can create disposal and pollution problems. A study by the Interstate Oil Compact Commission (IOCC) indicates that up to 25 million barrels of salt water are produced daily from the Nation's oil wells. Proper disposal of produced brines has been and continues to be of major concern to producing operators. Subsurface disposal is strictly regulated by state water resources agencies and disposal of salt water is not permitted in fresh-water streams (NPC, Environmental Conservation, 1972).

The principal causes of water pollution from barges transporting petroleum inland and on coastal waterways are loading and unloading operations, collisions, ship operations, such as bilge disposal and human error. Data compiled from the Pollution Incident Reporting System (PIRS) of the U.S. Coast Guard show that there were 295 spills attributed to barges in 1970. Average size of the spills was estimated to be approximately 66 barrels per spill. Even though spill control methods are being improved, increased movement of petroleum has increased this pollution problem.

Surface and Subsurface Land Quality - A potential source of land pollution is a blowout during drilling, but the frequency of blowouts is small. A well blowout, while not common, may occur at any time during exploratory or development drilling. If blowout preventers fail, a well may flow out of control for days or months until the pressure declines, rocks and debris lodge in the well hole and restrict the flow to a controllable rate, or a relief hole or other control operations are successful.

During a blowout, oil, gas, drilling mud and brines may be sprayed into the air. Wind-blown pollutants can damage surrounding vegetation and other resources. A blowout can also charge subsurface formations with gas, oil, or brine, endangering ground and surface water quality. Fire is a possibility and seriously complicates control operations.

The likelihood of a blowout usually is reduced by use of a blowout preventer--a large control valve that can be closed to stop or reduce the well flow. Although usually standard equipment, blowout preventers, like

any mechanical device, may malfunction when needed. One hundred and six blowouts occurred in drilling 273,000 wells in 8 major oil-producing states from 1960 through 1970. Most blowouts are from high pressure gas rather than oil.

The injury experience of the oil industry has been far less than that of mining. For example, injuries are about one-fourth of those attributed to coal mining. Moreover, historical injury rates of the oil industry are relatively constant, which indicates that increased production would not significantly increase the rate of additional fatalities.

(c) Transportation

Substantial oil production is normally served by a trunk pipeline to transport the crude oil to the refinery or to a shore terminal for transshipment by tanker to a refinery. Pipeline construction involves temporary disturbance of the terrain to the extent of excavating a trench, the construction of structures for crossing streams and the installation of pumping stations. Once a pipeline is completed, it normally is a benign environmental consideration and the terrain is returned to essentially its native condition. There is the possible hazard of an oil spill in case the line breaks but normal pipeline maintenance and safety measures, etc., are designed to prevent large or long continued spillage. Spills could occur from tankers or at the terminal and the proposed ballast treatment facility will have a discharge of treated ballast water which may contain residual amounts of oil.

In exploring and pipelining, spills that occur normally would be small. Major spills could occur in drilling, production and in transportation of petroleum liquids by marine transportation. The Environmental Protection Agency (EPA) estimated that 10,000 oil spills occur per year of which 2,500 are ground spills. Most ground spills cause little ground damage. According to the 1970 report of the Office of Pipeline Safety (Department of Transportation) on spills incidents, there were a total of 347 liquid pipeline accidents. Crude oil was being transported in 216 of the accidents. In those accidents, spills averaged approximately 1,780 barrels of crude oil. Principal cause of over 50 percent of the accidents was corrosion. Many pipelines are old, dating back to the 1920's before techniques for protection against corrosion became widely used. With the development and expanded use of cathodic protection of pipelines, fewer accidents in new lines would be expected, but accidents from old lines will continue to be of concern.

(d) Refining

Increased use of oil for electric power generation as a substitute for geothermal power could require an increase in refining or desulfurizing capacity to produce low-sulfur fuel oil. Such plants tend to be located close to the heavily populated areas near tidewater and deep ocean harbors. Some air pollution, thermal pollution and effluents of liquid

wastes normally are associated with refining or desulfurizing processes, but these are controlled to tolerable levels in most areas. Danger of explosions, fires, and oil spills exist in the process plants and associated oil storage areas. The incremental increase in capacity to produce low-sulfur fuel oil for power generation as an offset to geothermal energy, at least until after 1980, probably would be managed mostly by expanding existing plant capacity without significant increases in the adverse effects on the environment in the general vicinity. Thereafter, additional plants might be required if significant geothermal development does not take place.

(2) Increased Domestic Production - Alaska North Slope Oil

Under the Trans-Alaska pipeline proposal, North Slope oil would be delivered to the West Coast. If the Trans-Alaska pipeline as proposed is not built, West Coast oil needs probably would have to be met by additional foreign imports. The significance of North Slope oil to West Coast oil demand was shown in the introduction to this section. Additional North Slope oil, beyond that presently being developed, could be considered as a substitute supply to geothermal energy in the West Coast areas.

The broad range of potential environmental impacts associated with development and production of 2 million barrels of oil per day from the Alaska North Slope oil resources are comprehensively covered in the Department of the Interior's Environmental Impact Statement relative to the proposed Trans-Alaska pipeline (Interagency Task Force, 1972, Final Environmental Impact Statement-Proposed Trans-Alaska Pipeline).

The Prudhoe Bay field currently is estimated to contain 24 billion barrels of oil-in-place. At an estimated recovery rate of 40 percent, the current proved recoverable reserves of the field are 9.6 billion barrels of crude oil. These reserves alone make the Prudhoe Bay field the largest ever discovered on the North American continent (Halbouty, November, 1970). Nevertheless, the 9.6 billion barrel estimate may be a conservative indication of the crude oil potential of the field, the Arctic Slope province, and the adjacent regions of the Canadian Arctic.

Initial estimates of the reserves of newly discovered fields seldom indicate their full potential. As further drilling occurs, the proved area of pools is extended. Further developmental drilling and production provide additional information upon which more accurate estimates of reserves can be based. The application of secondary recovery techniques in the field also increases the amount of proved reserves.

The current reserve estimate for the Prudhoe Bay field is for unextended pools and assumes primary recovery only. Since the Prudhoe Bay discovery is quite recent and since relatively few wells were drilled at the time this estimate was made, it is highly probable that reserve estimates will increase as the field is developed. ARCO officials have recently indicated

that they hope to recover ultimately 65 percent to 70 percent of the oil-in-place (Oil and Gas Journal, April 17, 1972, p. 40). This increase in the recoverable percentage would increase present reserve estimates to 15.6 to 16.8 billion barrels of recoverable reserves from present estimates of oil-in-place. With the addition of possible extensions, it is likely that at least 20 billion barrels of crude oil will eventually be recovered from the Prudhoe Bay field. This would make it the fifth largest oil field ever discovered.

(3) Increased domestic production - Continental Shelf leasing and production

This alternative would require increased exploration, development, and production of crude oil from offshore areas in the lower 48 States and Alaska. To be effective, however, it would require that production from offshore areas be established over and above that production from operations conducted under the accelerated lease sale schedule. A significant increase in the production of crude oil supplies from offshore areas can come from development on existing leases and issuance of new leases and development of new reserves. However, such increase probably cannot be considered as an alternative to geothermal resource development since it already is programmed for accelerated development to meet rapidly growing domestic needs. The President, in his 1973 Energy Message, issued the following instructions relative to OCS leasing:

"Since 1954, the Department of the Interior has leased to private developers almost 8 million acres on the Outer Continental Shelf. But this is only a small percentage of these potentially productive areas. At a time when we are being forced to obtain almost 30 percent of our oil from foreign sources, this level of development is not adequate.

"I am therefore directing the Secretary of the Interior to take steps which would triple the annual acreage leased on the Outer Continental Shelf by 1979, beginning with expanded sales in 1974 in the Gulf of Mexico and including areas beyond 200 meters in depth under conditions consistent with my oceans policy statement of May, 1970. By 1985, this accelerated leasing rate could increase annual energy production by an estimated 1.5 billion barrels of oil (approximately 16 percent of our projected oil requirements in that year) and 5 trillion cubic feet of natural gas (approximately 20 percent of expected demand for natural gas that year).

"In the past, a central concern in bringing these particular resources into production has been the threat of environmental damage. Today, new techniques, new regulations and standards, and new surveillance capabilities enable us to reduce and control environmental dangers substantially. We should now take advantage of this progress. The resources under the Shelf, and on all our public lands, belong to all Americans, and the critical needs of all Americans for new energy supplies require that we develop them.

"If at any time it is determined that exploration and development of a specific shelf area can only proceed with inadequate protection of the environment, we will not commence or continue operations. This policy was reflected in the suspension of 35 leases in the Santa Barbara Channel in 1971. We are continuing the Santa Barbara suspensions, and I again request that the Congress pass legislation that would provide for appropriate settlement for those who are forced to relinquish their leases in the area.

The estimated reserves of the Prudhoe Bay field do not exhaust the petroleum potential of the Arctic Slope province in Alaska. The Prudhoe Bay field is located in the Colville Basin. Geologically, this basin is classified as an intermediate crustal type, i.e., its underlying crust is intermediate to that beneath oceans, the basin itself being extracontinental (located on the margin of a continent) and sloping downward into a small ocean basin. Extracontinental, downward warping basins are among the richest sources of oil and gas in the world. Examples of such basins include the Arabian platform and Iranian basin (Persian Gulf), the East Texas basin and the Tampico embayment (Mexico). Over one-half of the 119 known oil fields with at least 1 billion barrels of recoverable reserves are found in the 10 known basins of this type (Halbouty, 1970).

The ultimate potential on the onshore area in the Arctic Slope province (excluding the Arctic Wildlife Refuge but including Naval Petroleum Reserve No. 4) is uncertain. The platform along the Arctic coast gives considerable geologic indications of being very favorable for both oil and gas (Gryc, 1971). Comparison with the history of similar basins indicates a high probability of further discoveries of varying size. One estimate made prior to the release of detailed information on the Prudhoe Bay field suggested an ultimate recovery of up to 30 billion barrels for the province including speculative reserves (Crain). Other professional estimates made before and since that time (which incorporate higher recovery rates as well as greater optimism about additional discoveries) are somewhat higher, ranging up to 40 to 50 billion barrels. Considerably higher estimates than these have been made, but the geologic evidence for them is lacking.

Additional North Slope production beyond the 2 million bbls. per day now planned for West Coast delivery probably would go to the midwestern or eastern U.S. markets.

"At the same time, I am directing the Secretary of the Interior to proceed with leasing the Outer Continental Shelf beyond the Channel Islands of California if the reviews now underway show that the environmental risks are acceptable.

"I am also asking the Chairman of the Council on Environmental Quality to work with the Environmental Protection Agency, in consultation with the National Academy of Sciences and appropriate Federal agencies, to study the environmental impact of oil and gas production on the Atlantic Outer Continental Shelf and in the Gulf of Alaska. No drilling will be undertaken in these areas until its environmental impact is determined. Governors, legislators and citizens of these areas will be consulted in this process."

From 1954 through 1972, total offerings have been 4,073 tracts which included 15.3 million acres. Leases were awarded for 1,838 tracts totaling nearly 8.1 million acres. To date, approximately 2 percent of the potentially productive OCS lands have been leased. The Federal OCS has produced nearly 3 billion barrels of oil and 15 trillion cubic feet of natural gas. OCS leases are now producing over 400 million barrels of oil and 3 trillion cubic feet of natural gas annually. Thus, for 1971, the OCS production represented 7.2 percent of the total U.S. oil demand and 13.6 percent of the total natural gas demand.

In 1971, total domestic oil production was 4.1 billion barrels, and of this amount, 9.4 percent came from the OCS. Also, of the 21.2 trillion cubic feet of domestic natural gas produced, 12.5 percent came from the OCS. These production relationships are expected to increase rapidly as additional areas are leased and brought into production. Under an accelerated leasing program involving three lease sales annually of 1 million acres each, current estimates indicate the following potential relationships:

	Percent of Total Demand		Percent of Domestic Production	
	1985	1990	1985	1990
Oil	19.2	30.3	44.2	90
Gas	22.7	30.3	49	79

It must be recognized that estimates such as this involve numerous elements of great uncertainty, particularly in terms of the volume and timing of new discoveries onshore and offshore. They primarily indicate potential order of magnitude relationships.

The U.S. continental seabed area encompasses some 1,332 thousands of square statute miles:

Region	State lands*	Between State limit & 200 meter depth	Between 200 & 2,500 meter depths	Total
Hawaii	--	0.4**	3.6	4.0
Alaska	22.9	560.0	212.2	795.1
Wash., Ore., and Calif.	4.5	15.4	76.2	96.1
Gulf Coast	13.5	107.5	84.2	205.2
Atlantic Coast	7.1	122.0	102.5	231.6
Total	48.0	805.3	478.7	1,332.0 1/

* Areas within 3 nautical miles of coastline, except for Texas and the Gulf Coast of Florida where the boundaries are 3 leagues distant.
** Includes State areas.

Estimated United States OCS potential resources occurring originally in place may total as much as 1,400 billion barrels of oil. Of this amount, approximately 50 percent is estimated to be located within 200 meters and the remaining 50 percent between 200 meters and 2,500 meters.

The OCS is more attractive than onshore areas for oil and gas exploration because most of the promising onshore geologic provinces have been intensively investigated and the most accessible and favorable formations have been explored and developed. There still are large quantities of oil and gas to be discovered onshore; but exploration and development costs will be much greater due to the nature and depth of the prospective formations. By contrast, OCS areas have not been developed. There are many favorable prospective areas that offer great promise for significant production at reasonable cost.

Properly conducted petroleum exploratory and development operations should not have unacceptable adverse impacts on the environment of the offshore areas. However, if oil spills occur, these could result in extensive short-term damage to beaches and wildlife and temporary curtailment of other uses in the area of the spill. The long-term environmental effects of such a crude oil spill are not adequately known.

1/ Figures are square statute miles.

In March, 1973, the U.S. Geological Survey made the following estimates for the resource base of U.S. Offshore oil and gas on Federal lands:

U.S. Oil and Gas Reserves and Resources
(Oil* in billions of barrels; gas in trillions of cubic feet)

	Proved Reserves		Recoverable Resources **	
	Oil	Gas	Oil	Gas
Offshore ***				
Total	5.84	38.8	201.2	1,077.2
Alaska	--	--	62.0	280.0
Pacific	2.30	2.0	15.7	171.0
Gulf of Mexico	3.54	36.8	75.5	406.2
Atlantic	--	--	48.0	220.0

* Includes natural gas liquids
** Does not include proved reserves
*** Includes shelf and slope to 2,500 meter depth

Proved reserves are reserves calculated from numerous known parameters at the wellhead while recoverable resources include all other known oil and gas resources, less that amount which cannot be recovered. Recoverable resources figures are derived from a volumetric measure of sediment and from the best geologic information available.

(a) Exploration and production. The initial effort in offshore exploration involves geophysical exploration activity. Exploratory seismological surveys have little lasting impact. The principal effect is similar to the impact of surface use for commercial and sport boating on the marine environment. During development, some disposal into the sea of trash, debris, bilge wastes, and spills of crankcase oil and engine fuel probably will occur from a variety of crew boats, service vessels, tugs, and drilling rigs which operate in the offshore area. However, existing regulating actions of the Coast Guard and the Geological Survey are designed to eliminate or minimize these occurrences. As exploratory drilling vessels or rigs occupy a single location for a limited period of time, the duration and the seriousness of any adverse environmental impact on the immediate vicinity depends on the magnitude of any pollution occurring there as a result of surface winds, tides, currents, bottom scouring, and water temperature which tend to concentrate, dilute through dissipation, or transport pollutants elsewhere. Most adverse environmental impacts can be avoided by enforcement of regulations and controls. There are organized measures that will be taken if such spills do occur.

One of the major potentials for serious pollution of offshore waters by hydrocarbons is an uncontrolled flow of oil or condensate from wells drilled from platforms or drilling vessels. This could be either a blowout during drilling operations or production mishaps from a failure of facilities or human error. Normally, drilling muds and blowout prevention devices control the natural pressure in a well; nevertheless, blowouts do occur. Facilities can fail, thus causing a release of hydrocarbons into the ocean, but with proper design, installation, and maintenance under existing OCS orders, the frequency of such failures can be minimized. Adverse impact depends largely upon the amount of oil that escapes to the marine environment and local characteristics noted above which control the distribution of the resulting pollution. With proper safeguards, the adverse effects can be minimized.

Data compiled from the Pollution Incident Reporting System (PIRS) of the U.S. Coast Guard show that in 1970 there were 12 spills attributed to offshore oil wells. The total quantity of oil involved was estimated to be 111,900 barrels. When related to the 589,127,000 barrels of oil produced in offshore areas, spills attributed to offshore production are extremely small (0.02 percent). There were 23 spills attributed to offshore pipelines with only one of significant size. Twenty-two spills were estimated to average 5 barrels per spill. A total of 295 spills were attributed to barges. Average size of the spill was estimated at approximately 66 barrels per spill.

The construction of offshore drilling platforms can cause some temporary turbidity of the water which may damage aquatic life, including shellfisheries located on the ocean floor in the immediate vicinity of the facility; however, such turbidity would occur only during the setting of the platform structure.

As of August 31, 1972, over 1,893 platforms, including single and multiwell structures, have been installed in OCS Gulf of Mexico waters. Turbidity resulting from the placement of drilling and production platforms involves a small area and is of short duration. Destruction of the benthos is also confined and only involves a few square feet for each piling.

Since the advent of offshore oil and gas activities, many species of fin fish have become concentrated around the drilling structures, which provide an artificial habitat. Among these are: red snappers, groupers, trigger fish, spade fish, giant sea bass, pompano, and many smaller species. There is evidence that these species and other larger seasonal game fish, such as sail and bill fish have appeared since the offshore oil industry became active. The platforms create unique offshore artificial environments which attract and concentrate many predatory species, providing favorable fishing sites for sportsmen and commercial snapper fishermen. The long-term effects of this intense species concentration, in lieu of the more random distribution patterns, are not known, but natural predatory-prey relationships could be affected.

Platforms and drilling rigs in view of land may disturb the scenic views and vistas of coastal inhabitants and tourists and the open space qualities of the seascape. The distance from shore at which a structure can be seen is mainly a function of the height of the structure and visibility. For example, a 100-foot high platform drops below the horizon at 16 miles while a 169-foot high platform disappears at 20 miles. Visibility conditions may also reduce the distance at which a platform may be seen.

Despite the installation of navigational aids, the erection of additional platforms on the OCS, particularly those adjacent to fairways, is a potential hazard to shipping. Safety fairways have been established to permit safe passage of vessel traffic into and out of ports. Anchorage areas are similarly designated for safety purposes. While exploratory drilling in shipping lands is permitted with approval by the Corps of Engineers, installation of fixed structures is prohibited under 33 U.S.C. 403 and 43 U.S.C. 1333(f). Production can be initiated by directional drilling from a portion of the tract outside the lane or from adjacent leaseholds outside of fairways. In some cases, platforms act as aids to navigation by providing a reference point from which a ship may find its position. They have also been used as refuges by sport fishermen in rough weather.

Platforms may be obstacles to commercial fishing when fish trawling equipment is used. The noise of drilling rigs, acoustical warning devices, and support vessel traffic operating in rivers, canals, and on the open sea could also be expected to have an effect on the coastal area environment.

Debris means those substances which are discharged or thrown into the sea (excluding waste water) as the result of a platform or support operation.

The improper disposal of this debris (trash, drilling muds, bilge wastes, and spills of crankcase oil and engine fuel) characterizes other possible kinds of vessel or platform-related sources of pollution. Toxic debris such as paints and thinners can poison and cause the death of some organisms. Floating nonbiodegradable debris is unsightly to tourish and recreational use and poses a hazard to small craft. Sinking debris can foul and damage commercial fishing nets. It may act as an artificial reef. Some of the biodegradable material may be eaten by some marine organisms. The amount of debris discharged into the environment as a result of OCS operations has been found to be small due to enforcement of pertinent regulations. For an extensive discussion of all types of debris, including regulations and methods of enforcement concerning their discharge, see the aforementioned OCS Statement.

(b) Oil spills. During the period 1964-1971, 39 significant recorded oil spills involving 50 barrels or more of oil and condensate occurred on Federal OCS lands. 1/ The estimated total volume of oil spilled as a result

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1/ Data taken from a table prepared by Offshore Operations Section, U.S. Geological Survey, "Accidents Connected with Federal Oil and Gas Operations in the Outer Continental Shelf Thru 1971."

of these incidents is slightly less than 280,000 barrels. During this same period, more than 2 billion barrels of oil and condensate were produced in the Gulf of Mexico, offshore Texas and Louisiana, and on the Pacific Coast OCS. The amount of recorded spills represent approximately 0.014 percent of the oil and condensate produced in the OCS during the same period.

Year	Number of Incidents	Total Production/bbl.	Total Spilled/bbl.	% of Production Spilled
1964	5	122,500,126	14,928	0.0122
1965	1	144,968,615	500	0.0003
1966	0	188,714,070	0	0
1967	2	221,861,614	160,704	0.072
1968	2	266,936,001	6,085	0.0023
1969	8	302,919,143	10,924	0.0036
1970	7	335,658,540	84,323	0.0251
1971	20	387,445,398	1,473	0.0004

The number of incidents shows an increase starting in 1969. This is the same year that Gulf of Mexico OCS operating orders became effective requiring the recording of all spills, reporting of all spills greater than 15 barrels, daily inspection of manned facilities, and regular inspections of unmanned facilities. There has been a total of 10 oil spills of 1,000 barrels or more in over 18 years of OCS leasing. Six out of the 10 major oil spills occurred during the period from 1964-1968 and four during the period following implementation of the OCS operating orders of 1969-1971.

During the first 9 months of 1972, 839 minor spills of less than 50 barrels involving 836 barrels (42 gals/bbl) of oil were recorded by the Geological Survey from OCS oil and gas operations in the Gulf of Mexico. The majority of these spills (682) involved 1 barrel of oil or less totaling 170 barrels. Only five spills exceeded 15 barrels of oil (141 barrels). An additional 499 oil slicks from unidentified sources were sighted in the first 9 months of 1972 and are not positively related to offshore drilling. There is evidence of natural oil seepage in the Gulf of Mexico and possibly these natural seeps could be the source of some oil slicks classified as being from an "unidentified source."

Blowouts during exploratory drilling pose the greatest potential for serious pollution of offshore waters by hydrocarbons and of air quality by fire. Normally, drilling muds and blowout prevention devices control the natural pressure in a well; nonetheless, blowouts do occur. From June 9, 1956, to July 18, 1971, 35 blowouts occurred on Federal OCS oil and gas operations. Ten of the 35 blowouts resulted in a total oil or condensate spillage of 79,680 barrels. Fire occurred in 10 of the 35 blowouts; eight of the firestburned gas only. During the 15-year period, 10 blowouts resulted in oil or condensate spills into the water and two of the 10 blowouts had oil fires which impacted on air quality.

Since 1954, there have been 11 major oil spills (both blowouts and pipeline incidents) of 1,000 barrels or more. Three of the 11 major spills were the result of pipeline ruptures or leaks and the remaining were the result of accidents which occurred on specific platforms and tracts during operations. Historically, this represents a ratio of one major oil spill per 141 tracts leased, and one major spill resulting from pipeline breaks and ruptures per 518 tracts leased.

(c) Collisions resulting from conflict between ship navigation and offshore structures. During the period July 1, 1962, through June 30, 1971, the Coast Guard recorded 24 incidents of collisions between vessels and fixed platforms. Total damages were estimated to be about $0.4 million to vessels and $3.4 million to the structures. Only four injuries and no deaths were reported. During the time period 1957-1971, the Geological Survey recorded only one significant spill of oil--2,560 barrels--associated with ship-platform collisions.

(d) Accidental deaths and injuries on oil industry structures and vessels. Information supplied by the U.S. Coast Guard reveals that a total of 94 individuals were killed as a result of accidents involving construction and operation of drilling vessels, workboats, mobile drill rigs, and artificial islands in the Gulf of Mexico and adjacent navigable inland waters during the period 1964-1971. Of these 94 deaths, approximately 60 occurred in water approximately equal to the Federal OCS area. These figures do not include deaths resulting from accidents in which no vessel or rig damage occurred (i.e., persons falling or knocked overboard, crushed by drilling equipment, etc.). Partial figures for fiscal years 1967 through 1971 indicate that approximately 25 persons were killed in oil operations in the Gulf of Mexico (both inland and international waters) where no casualty to the vessel was involved.

(e) Environmental impacts. The marine environment is rich in both its variety and number of marine life. Pollution affects, in varying degrees, all forms of marine plant and animal life throughout the food chain. The precise effects of oil spillage on the marine food chain or food web (which consists of plants, bacteria, and small marine organisms) are not well understood because of the side fluctuations and cycles that occur naturally and are totally independent of the effects of oil. The degree of pollution, duration, constituency of the fuel, and the physical conditions under which it occurs determine the extent of the impact. After pollution has occurred, a normal balance may be regained in a short period of time or the impact may be more severe with recovery requiring a span of many years. Little is known of what effect the chronic incremental discharge of oil, associated with normal drilling and production operations, may have on the marine food web. In any case, the normal "health" of the ecosystem is disrupted and a balance is lost during the period of recovery.

Pelagic seabirds frequently are the most obvious victims of oil pollution because they are likely to come into direct contact with the oil. Contamination of oil destroys the waterproof qualities of their plumage, a condition from which they seldom recover, even when careful rehabilitation is attempted. Harm to the birds from contact with oil is reported to be the result of a breaking down of the natural insulating oils and waxes shielding the birds from water with the consequent loss of body heat. The 1969 Santa Barbara oil spill resulted in the known death of 3,686 birds and many marine organisms at the intertidal zone. Efforts to cleanse or rehabilitate contaminated birds generally have been unsuccessful. Less than 20 percent of the treated birds survived the Santa Barbara cleanup attempts. Similarly, bird species are vulnerable if beaches and marshes become contaminated by oil, especially if vegetation and food sources are destroyed. In the northern hemisphere, hundreds of thousands of swimming and diving birds have perished from oil pollution during and since World War II, and a marked reduction of some nesting populations of sea birds from such mortality has been documented (Aldrich, J.W., 1970). However, no such problems has been documented in the Gulf of Mexico as a result of oil spills on the OCS.

Equipment and procedures for recovering oil spilled in protected waters are well developed, but similar capability in the open sea is limited. There are no recovery devices capable of picking up oil in rough seas with wave levels over 5 feet. The use of sorbents which have an affinity for oil poses specific problems: distributing sorbent over the area affected by the oil spill is difficult, particularly in high winds; there is no effective procedure for collecting the sorbent after contact with spills; and treating or disposal of such oil-saturated materials is difficult. The chemical and physical process and potential impacts of sinking oil to the ocean bottom is particularly undesirable in shellfish producing intertidal areas. The use of dispersants on spills introduces the problem of toxicity of such materials if they are poorly handled or are not properly diluted in the water column (NPC, 1972).

Marine life also may be affected by efforts to remove the surface oil. Emulsifiers as well as natural storm action remove oil from the surface by redistributing it as minute droplets throughout the water column. In this condition, oil is more susceptible to biological and chemical degradation, although in combination with such chemicals it is usually more toxic. Furthermore, the oil-treating chemicals themselves have been found to be more toxic than crude oil in many instances.

Nearshore, estuarine, and coastal environments are adversely affected as a result of oil spills if current and wind conditions are such that the spilled oil is transported shoreward in large amounts. Beaches, water recreation areas, and historic sites could be rendered temporarily unusable, resulting in a loss of recreational enjoyment and economic benefit to the local populace.

Water sports such as swimming, diving, spearfishing, underwater photography, fishing for finfish and shellfish, boating, and water skiing would be most directly affected. Other marine-related activities such as beachcombing, shelling, seascape painting, shoreline nature study, camping, and sunbathing would be made much less attractive for an indeterminate period, depending upon the promptness and efficiency of the cleanup effort.

Much more critical in terms of total value is the degradation of estuarine and marsh areas which are vital to the ecology as nursery grounds. There has been one case where mortality of organisms in the immediate area of a No. 2 fuel oil spill was relatively high (95 percent), and within one year after the spill, repopulation was occurring at most of the stations of the study. Larvae of the commercially important species such as oysters, crabs, and shrimp which use marshes and estuaries to feed and grow are also affected by spilled hydrocarbons. Continued research on the impact of oil spills on onshore organisms will provide more definitive answers to the questions of mortality and repopulation by indigenous organisms.

(f) Waste Water. A production element which can contribute to offshore pollution is the disposal of waste water associated with oil production. Although the volume of such waste discharge may be small, an increase in offshore oil activity and the advancing state of depletion of water-drive fields will cause waste of this kind to be an important consideration. The oil content of waste water discharged as a result of OCS operations is limited to an average of not more than 50 ppm under OCS Order No. 8.

In Federal areas offshore Louisiana, 1,935 structures produce a total of 1 million barrels of oil per day; waste water is discharged from approximately 214 of the structures. Total waste water production is about 420,000 barrels per day; 240,000 barrels are transported to shore and 180,000 barrels are discharged into the sea. The largest volume of waste water discharged at a single location is approximately 20,000 barrels per day. The decision to separate, treat, and discharge waste water on the platform or pipe it to shore depends primarily on whether or not space exists on the platform for separating facilities and if pipeline capacity is available. The oil content of waste water discharged in OCS operations in the Gulf of Mexico, which averaged 40.8 ppm in March 1972, can contribute as much as 7.3 barrels of oil per day to the Gulf of Mexico waters.

During 1971, approximately 16 barrels of oil may have been introduced into the ocean daily, either from minor spills or waste water discharge. Based on these figures, each increase in production of 100,000 barrels per day could contribute an additional 1 to 3 barrels of oil per day from continuous pollution sources on the OCS in addition to spills from unidentified sources.

There is little research on the effects of waste water discharge on the environment. Two studies to date have produced diametrically opposite results. One study indicated that due to the extreme salinity (between 6.1 and 27.0 percent dissolved salts), and the difference in proportion of salts in waste water and sea water, that where quantities were dumped into a stream the biota was destroyed. When the brine was diluted measureably by rainfall, the fauna moved back into the area of pollution. The other study observed that results of brine effluent in a stream had no observable effect at a distance of a few feet from the discharge pipe. The study goes on to state that there may even be a "fertilizing" effect due to the introduction of the brine. These studies are, at best, minimal evidence on which to base a sound judgment of the effect of waste water on the environment.

(g) <u>Pipeline construction</u>. Pipelines laid offshore are buried (required by BLM administrative procedures for water depth of 200 feet or less) to avoid the danger of being struck or dragged by ship anchors as well as to avoid movement in the event of strong water currents in times of intense storms such as hurricanes. Approximately 98 percent of the oil and all the natural gas produced offshore is transported to shore by pipeline and the remaining 2 percent is transported by barge. Although well blowouts attract the most attention, spillage of oil due to the rupture of pipelines which transport offshore production to shore terminals can be serious. During the last decade, ruptured pipelines caused more pollution than drilling and production operations. From 1967-1971, there were nine pipeline breaks or leaks of 50 barrels or more connected with OCS oil and gas operations, totalling 174,848 barrels. The largest, a spill of 160,639 barrels of oil caused by a pipeline leak due to anchor dragging, occurred on October 15, 1967.

Pipeline construction in marsh areas resulting from OCS operations will cause temporary damage and disturbance of benthic organisms. Depending upon existing environmental conditions, some of this damage may be permanent. When pipelines are buried in coastal marshes, it has been a common practice to dredge canals in which to place them. Such pipeline canals increase the ratio of water to wetlands by physically removing the coastal marshes, by facilitating drainage of fresh water necessary to maintain diluted conditions in the estuaries, and by increasing the rate of salt water intrusion from the more highly saline coastal waters. The dredging and redepositing of the displaced sediment also disturbs the local habitat of aquatic plants and animals. Recent studies made by Louisiana State University (1970) indicate that 16.5 square miles of marsh have been destroyed each year in coastal Louisiana by erosion, subsidence, and construction. Most of this destruction is attributable to natural causes, including hurricanes, but some annual marsh destruction can be attributed directly to canal dredging operations associated with the oil industry and to construction of pipeline canals. Some of these pipeline canals serve onshore production and others serve offshore production.

Adverse effects of pipeline construction may be either short-term or permanent and may be minor or serious, depending on the methods employed in laying pipelines and their location. These effects can be substantially reduced with adequate planning and by using the most appropriate construction techniques. Usually bulkheads are placed in canals to prevent saltwater intrusion and to maintain existing drainage and water-exchange routes. To protect oysters, pipelines are usually routed around major oyster reefs and, where shallow estuaries are to be crossed, the canal is usually backfilled as is often the case with canals through marshlands.

A ditching or jetting operation associated with construction of offshore areas generally causes temporary turbidity of the water in the immediate vicinity and may temporarily disturb fish and other aquatic life during that time. It is possible that the operation may also temporarily damage a portion of any shell fisheries existing in the immediate area.

(h) Summary. Even with the best systems and controls, some oil pollution from OCS leasing will occur. The recently strengthened regulations and operating orders 1/ are as stringent as technology allows at this time. Although increased Federal inspections and the large costs involved in controlling, containing, and cleaning up spilled oil have combined to generate an awareness of the necessity to improve OCS safety, no regulation or enforcement can guarantee that there will be no pollution from oil producing operations. Natural disasters, equipment failure, or human error could occur despite regulations and enforcement procedures. Federal enforcement and regulation procedures and better equipment and engineering standards, although they cannot guarantee there will be no spillage, have served to reduce the risk of oil spill accidents and pollution incidents resulting from OCS development.

An increased level of conflict and navigational hazard will result from additional offshore structures associated with OCS development. The greatest effect will be on commercial shipping and fishing activities. Increasing the numbers and lengths of pipelines to shore will have its greatest impact in nearshore and onshore areas, i.e., estuaries, marsh, and wetlands environments. The biota in the path of a pipeline will undergo disruption, loss of habitat, and will suffer physiological stress, injury, or death. In addition to pipelines, additional increments of transportation, storage, refinery, treatment, and other facilities and activities associated with oil and gas production on the OCS will have an overall, cumulative effect on the coastal environment and local and regional economies. The initial effect on biota will be one of disruption and destruction in the construction areas. A cumulative effect will result from solid, liquid, and gaseous waste disposal associated with OCS development and any oil polluting events should they occur. The quality

1/ Including the National Oil and Hazardous Substances Pollution Contingency Plan, 36 FR 16215, August 20, 1971.

of air over a developing area could be degraded by exhaust emissions of stationary power units and service vessels and by the accidental release of oil and gas from wild wells. The effect will be physiological stress and death for oiled plants and animals and possible contamination of marine food sources for man. The scope, duration, location, and overall significant effects of an oil spill on a cumulative basis are unknown. However, the areas of greatest potential for receiving lethal and sublethal adverse effects on a cumulative basis are embayments and semi-enclosed waters where many species undergo early development and are more vulnerable to toxic compounds. Oil on a beach would be aesthetically unpleasant and would disrupt recreational events and usually render affected beach areas unsuitable for human enjoyment.

General Summary of Environmental Impacts Which
Might Result from OCS Oil and Gas Operations 1/

Impact Sustaining Factors	Impact Producing Factors							
	Debris	Plat-form	Oil Spill	Pipel Const	Storage Facil.	Support Serv.	Labor Force	Prod.
1. Refuges	(-)		(-)	4/	4/			
2. Estuaries	(-)		(-)	(-)				
3. Marshland	(-)		(-)	(-)	(-)	(-)		
4. Beaches	(-)	2/	(-)	4/	4/			
5. National Park Units	(-)	2/	(-)	4/	4/			
6. Com. Fish.	(-)	(-)	3/	5/				
7. Sport Fish.	(+)	(+)	3/	5/				
8. Recreation	(-)	2/	(-)					
9. Shipping		(-)						
10. Regional Economy		(+)		(+)	(+)	(+)	(+)	(+)

1/ The principal type of relationship between impact producing and sustaining factors is indicated by (+) positive impact or (-) negative impact. In some relationships, both positive and negative relationships are possible, in these areas, the type of relationship considered dominant is shown.

2/ Impact will be negative only if platforms are visible, i.e., impact will be on aesthetic values.

3/ Impact of oil pollution on nearshore and estuarine shellfish is negative; impact on open-water finfish and shellfish is not well understood, but oil spills adversely affect sport and commercial fishing activity.

4/ Impacts would be excluded by administrative action, e.g., pipelines or storage facilities would not be permitted in refuges, National Park Units, or on those recreation beaches subject to official regulation.

5/ Impacts would occur during construction stage only.

(4) Elimination of Market-Demand Prorationing Systems

This alternative would require those states which prorate oil production to market demand to revise their laws and regulations so as to permit full production. Important exceptions to production at maximum efficient rate (MER) currently remain only in the Elk Hills Naval Petroleum Reserve (which is not subject to state market-demand prorationing) and a small number of fields in Texas and Louisiana. Ray T. Sutton, the Commissioner of Conservation of the State of Louisiana, has testified that "the onshore and Zone 1 production has peaked and is in a period of steady decline... For all practical purposes, Louisiana is now producing all the oil that can be produced efficiently. We have no reserve producing capacity." * Furthermore, the Commissioner added, unsatisfied market demand (as measured by nominations) exceeded 100,000 barrels per day in August 1972.

Only three large Texas fields--East Texas, Kelly-Snyder, and Tom O'Connor --were restricted below 100 percent of their respective market-demand factors as of January 1973. Conservation problems encountered at higher operating rates have compelled reduced production in these fields while unresolved issues of correlative rights to the crude oil also preclude higher production from East Texas. The Chairman of the Railroad Commission of Texas, Byron Tunnel, has stated, "Texas has no significant reserve-producing capacity remaining." He noted that an increase of Texas allowable percentages by 32.5 percent achieved only a 12 percent increase in oil production, and concluded, "We have reached the peak of production at which Texas oil fields can be operated without harm to the reservoirs. Do not count on Texas for more oil and gas than is now being produced. It simply isn't there." In January and February 1973, Texas allowables were 100 percent of MER and production is currently 300,000 barrels per day less than purchasers say they need to meet demands (New York Times, Jan. 19, 1973, p. C4).

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* Public Hearing of August 22 and 23, 1972, on proposed Louisiana OCS Oil and Gas General Lease Sale and Draft Environmental Statement, New Orleans.

(5) Increased Oil Imports

In the event that geothermal power development is not implemented, imported oil could be a freely substitutable source. However, its use for electric power generation represents a relatively small part of the energy demand to be supplied by projected imports. Thus, it probably would have little bearing on major decision making with regard to oil imports. However, in view of the mobility of oil and finished products, any actions which could reduce oil demand in the western states could have a beneficial effect on other regions by reduction in competition for domestic or foreign oils. The environmental impact of increased imports arise mainly from three sources: (1) increased ship traffic, (2) the transportation of the oil from offshore terminals to coastal refineries and thence to power plants, and (3) consumption of the oil at the power plants.

At the present level of geothermal generating capacity of 298 MW, an increase in the oil equivalent (4 million barrels per year) would result in a negligible increase in tanker traffic. The U.S. Coast Guard, in a section prepared for the Trans-Alaska Pipeline Environmental Impact Statement, assumes an average tanker load of 800,000 barrels per vessel. Thus, only five tanker trips per year would be required for an imported oil substitution.

At the higher projected levels of geothermal capacity of 1,000 to 2,000 MW and 7,000 to 20,000 MW, roughly 15 to 30 and 100 to 300 tanker trips per year, respectively, would be required. These higher levels probably could be accommodated with existing facilities provided additional imports are not also needed to meet other demands, If the combination were significant, additional facilities might be required. The environmental impacts would be in rough proportion to the amount of oil handled by existing and/or new facilities.

(a) U.S. dependency on imports

The United States is heavily dependent upon liquid and gaseous fuels that presently can be obtained only in the quantities needed from conventional petroleum sources, both foreign and domestic. This situation will continue for the next 10 or more years regardless of the progress made in the extraction of liquids and gases from coal and oil shale or the development of other energy sources such as geothermal because long lead times are necessary to develop these supplemental sources. The adequacy, security, and cost of petroleum supplies can have a direct influence on the Nation's national product, trade position, diplomatic posture, and military capability.

Following is a summary of expected demand for petroleum, the expected domestic production, and supplemental supplies that will be required to fulfill demand (Interior, 1972). Through 1980, if domestic production is not stimulated, these supplemental supplies will have to come in the form

of increased imports. After that time, incremental production may be possible from some synthetic sources (oil shale, tar sands, etc.), but imports still will provide the predominant portion.

	Million barrels/day			
	1975	1980	1985	2000
Total petroleum demand	17.4	20.8	25.0	35.6
Total domestic production	11.0	11.7	11.7	10.5
Supplemental supplies	6.4	9.1	13.3	25.0
Percentage of imports	37	44	53	70

The National Petroleum Council's analysis of the energy situation provides other projections of imports through 1985. For its analysis, the NPC developed four different cases based upon varying economic conditions and oil and gas finding rates. Case I represents the best of conditions while Case IV represents the worst and Cases II and III are intermediary conditions. The following table presents NPC's projections of imports that will be needed to balance demand.

Projected Level of Oil Imports (NPC)
(millions of barrels/day)

Case	1975	1980	1985
I	7.2	5.8	3.6
II	7.4	7.5	8.7
III	8.5	10.6	13.5
IV	9.7	16.4	19.2

Source: National Petroleum Council, U.S. Energy Outlook, December 1972.

(b) Oil import policies

Until President Nixon's Energy Message of April 18, 1973, imports of crude oil, unfinished oil, and oil products were limited under the Mandatory Oil Import Program established in 1959 by Presidential Proclamation 3279. In his message, the President stated:

"In order to avert a short-term fuel shortage and to keep fuel costs as low as possible, it will be necessary for us to increase fuel imports. At the same time, in order to reduce our long-term reliance on imports, we must encourage the exploration and development of our domestic oil and the construction of refineries to process it.

"The present quota system for oil imports--the Mandatory Oil Import Program--was established at a time when we could produce more oil at home than we were using. By imposing quantitative restrictions on imports, the quota system restricted imports of foreign oil. It also encouraged the development of our domestic petroleum industry in the interest of national security.

"Today, however, we are not producing as much oil as we are using, and we must import ever larger amounts to meet our needs.

"As a result, the current Mandatory Oil Import Program is of virtually no benefit any longer. Instead, it has the very real potential of aggravating our supply problems, and it denies us the flexibility we need to deal quickly and efficiently with our import requirements. General dissatisfaction with the program and the apparent need for change has led to uncertainty. Under these conditions, there can be little long-range investment planning for new drilling and refinery construction.

"Effective today, I am removing by proclamation all existing tariffs on imported crude oil and products. Holders of import licenses will be able to import petroleum duty free. This action will help hold down the cost of energy to the American consumer.

"Effective today, I am also suspending direct control over the quantity of crude oil and refined products which can be imported. In place of these controls, I am substituting a license-fee quota system.

"Under the new system, present holders of import licenses may import petroleum exempt from fees up to the level of their 1973 quota allocations. For imports in excess of the 1973 level, a fee must be paid by the importer.

"This system should achieve several objectives.

"First, it should help to meet our immediate energy needs by encouraging importation of foreign oil at the lowest cost to consumers, while also providing incentives for exploration and development of our domestic resources to meet our long-term needs. There will be little paid in fees this year, although all exemptions from fees will be phased out over several years. By gradually increasing fees over the next two and one-half years to a maximum level of one-half cent per gallon for crude oil and one and one-half cents per gallon for all refined products, we should continue to meet our energy needs while encouraging industry to increase its domestic production.

"Second, this system should encourage refinery construction in the United States, because the fees are higher for refined products than for crude oil. As an added incentive, crude oil in amounts up to three-fourths of new refining capacity may be imported without being subject to any fees. This special allowance will be available to an oil company during the first five years after it builds or expands its refining capacity.

"Third, this system should provide the flexibility we must have to meet short and long-term needs efficiently. We will review the fee level periodically to ensure that we are imposing the lowest fees consistent with our intention to increase domestic production while keeping costs to the consumer at the lowest possible level. We will also make full use of the Oil Import Appeals Board to ensure that the needs of all elements of the

petroleum industry are met, particularly those of independent operators who help to maintain market competition.

"Fourth, the new system should contribute to our national security. Increased domestic production will leave us less dependent on foreign supplies. At the same time, we will adjust the fees in a manner designed to encourage, to the extent possible, the security of our foreign supplies. Finally, I am directing the Oil Policy Committee to examine incentives aimed at increasing our domestic storage capacity or shut-in production. In this way we will provide buffer stocks to insulate ourselves against a temporary loss of foreign supplies."

Under the previous quota system, the level of petroleum imports was restricted on the basis of product (commodity), geographical area in the United States, and, in some instances, country of origin.

Through April 30, 1974, under the new program importers will not be required to pay a fee on their previously allocated import levels. The amount of duty-free imports which will be permitted will be reduced each year until reaching zero in 1980. The license fee will also change over time. It also will be reassessed from time to time to be sure that the goals of stimulating domestic production and increasing refinery capacity are being met.

(c) Sources and distribution of imports

In the past, the United States has received most imports from Western Hemisphere sources. Because of increasing domestic demand in these countries, it is not likely that they will be able to meet the future U.S. need for imports. Table IV-14 shows estimates made by the NPC of Western Hemisphere liquid hydrocarbon supply-consumption balances. The estimates are based on their Case III supply estimates. In 1960, the Western Hemisphere was able to essentially maintain a balance in the supply and consumption of petroleum. This balance was almost achieved again in 1965.

The availability of Latin American oil was a major factor in reaching these balances. In the future, however, the increases in Latin American consumption are expected to be greater than increases in production. This factor combined with the great increases in United States consumption will cause increasing deficits in the Western Hemisphere petroleum supply-demand balance.

Future increases in oil imports therefore will come primarily from the Middle East and North Africa where as much as 80 percent of the non-communist world oil reserves may lie.

The bulk of oil imports in the past have entered PAD District I. This district has a high demand for oil caused by a concentration of population and industry and very limited oil production. Table IV-15 shows the 1972 supply distribution and balances for the five districts. Some 66 percent

Table IV-14

WESTERN HEMISPHERE LIQUID HYDROCARBON SUPPLY—OIL CONSUMPTION BALANCE (1960-1985)*
(MMB/D)

	1960	1965	1970	1975	1980	1985 Low	1985 High
Local Oil Consumption (Excluding Exports)							
United States	9.8	11.5	14.7	18.3	22.3	25.8	
Canada	0.9	1.1	1.5	1.9	2.3	2.7	3.0
Latin America	1.7	2.1	2.8	3.9	5.1	6.5	7.0
Total Western Hemisphere	12.4	14.7	19.0	24.1	29.7	35.0	35.8
Conventional Liquid Hydrocarbon Production							
United States	8.0	9.0	11.3	9.8	11.6	11.8	
Canada	0.5	0.9	1.5	2.2	3.0	3.7	
Latin America	3.8	4.7	5.3	5.8	6.7	7.0	
Total Western Hemisphere	12.3	14.6	18.1	17.8	21.3	22.5	
Synthetic Liquid Production							
United States	–	–	–	–	0.1	0.5	
Canada	–	–	–	–	0.4	1.0	
Latin America	–	–	–	–	0.3	0.8	
Total Western Hemisphere	–	–	–	–	0.8	2.3	
Total Liquid Hydrocarbon Production (Conventional Plus Synthetic) Available for Net Export or (Imports Required)							
United States	(1.8)	(2.5)	(3.4)	(8.5)	(10.6)	(13.5)	(13.5)
Canada	(0.3)	(0.2)	–	0.4	1.1	2.0	1.7
Latin America	2.1	2.6	2.5	1.9	1.9	1.3	0.8
Total Western Hemisphere	–	(0.1)	(0.9)	(6.2)	(7.6)	(10.2)	(11.0)

* All estimates are on a Case III supply basis.

Source: N.P.C. U. S. Energy Outlook, p. 262.

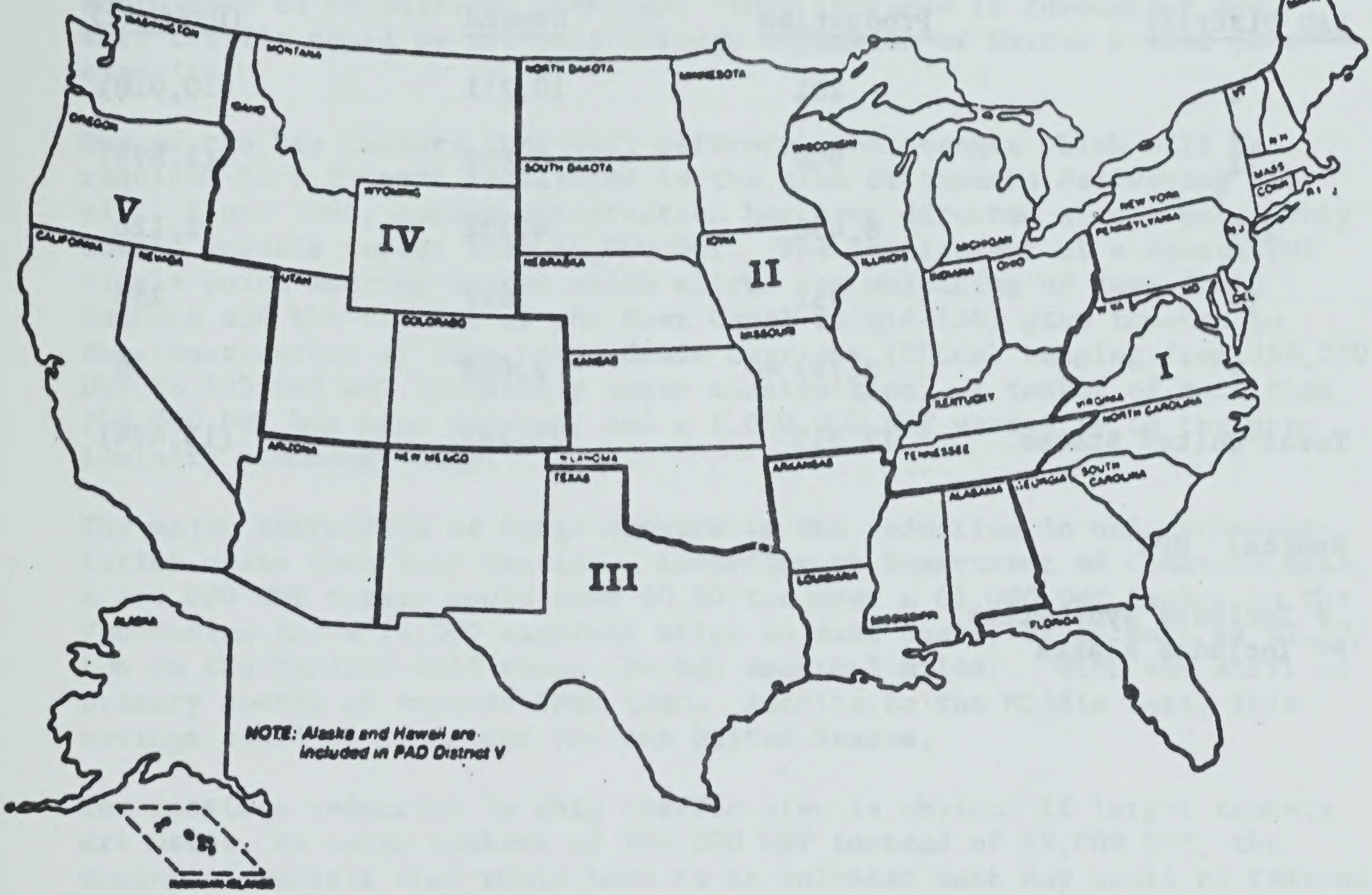
Table IV-15
1972 Supply Distribution and Sources
(Thousand barrels per day)

	Production Crude oil & NGL	Domestic Receipts: Crude and NGL		Domestic Receipts: Refined Products		Imports: Crude and NGL		Imports: Refined Products	
District I	88		284		2,996		971		2,162
		(II)	24	(II)	61	Canada	113	Canada	91
		(III)	257	(III)	2,932	Other West. Hem.	243	Other West. Hem.	1,863
		(IV)	3	(IV)	--	Africa	402	Europe	170
		(V)	--	(V)	3	Middle East	213	Africa	28
								Middle East	8
								Other E. Hem.	2
District II	1,279		1,812		759		513		64
		(I)	--		141	Canada	492	Canada	46
		(III)	1,552		594	Other West. Hem.	2	Other West. Hem.	13
		(IV)	260		24	Africa	13	Europe	5
						Middle East	6		
District III	7,943		21		73		77		49
		(I)	9		73	Other West. Hem.	21	Other West. Hem.	43
		(II)	5		--	Europe	1	Europe	4
		(IV)	7			Africa	53	Africa	1
		(V)	--			Middle East	2	Middle East	1
District IV	677		--		53		70		15
				(III)	27	Canada	70	Canada	15
				(V)	26				
District V	1,193		37		145		671		149
		(III)	2	(III)	64	Canada	266	Canada	17
		(IV)	35	(IV)	81	Other West. Hem.	33	Other West. Hem.	70
						Africa	1	Middle East	38
						Middle East	205	Other E. Hem.	24
						Other E. Hem.	166		

Bureau of Mines
Mineral Supply
March 26, 1973

of the total imports were to the east coast. Table IV-16, which shows 1985 PAD District supply and demand balances based on NPC's Case III, indicates that PAD District I will continue to have large deficits. In 1985, District I will require shipments of about 10 million barrels/day. Even if all surplus domestic production were shipped to District I, which seems unlikely given the projected deficit in District II, there would still need to be about 7.4 million barrels/day of foreign oil brought into the east coast.

Petroleum Administration for Defense (PAD) Districts



Problems with the security of supply, balance of payments, and United States off loading terminal capacity could arise due to an increase in imports. Using the Department of Interior projections of import levels, oil imports by source could be: (million barrels/day)

	1975	1980	1985* Low	1985* High
Western Hemisphere	2.3	3.0	3.3	2.5
Eastern Hemisphere	4.1	6.1	10.1	10.9
Total imports	6.4	9.1	13.4	13.4

* Low and high values refer to the expected Western Hemisphere oil consumption in Table IV-17.

Table IV-16 U.S. Petroleum Liquids Production* and Demand - NPC Case III (Thousands of barrels/day)

PAD District	Production	Demand	Surplus (Deficit)
I	201	10,211	(10,010)
II	906	6,859	(5,899)
III	6,458	4,332	2,126
IV	952	697	255
V	3,742 **	3,688	54
Total United States	12,313	25,787	(13,474)

Source: NPC

* Includes synthetics.
** Includes Alaska

(d) Tanker and terminal requirements

In 1971, total tanker arrivals for the lower 48 States were 67,770. Of these arrivals, 56,700 (84 percent) were in PAD District I; 6,650 were in PAD District III (10 percent); and 4,420 were in PAD District V (6 percent). Many of the shipments were of products from the Gulf coast and the Caribbean to PAD District I. The average size of tankers carrying imported crude was 29,000 DWT. 1/ To deliver 1971 imports of 3.0 million barrels/day would have required the unloading of the equivalent of 15 29,000 DWT tankers each day. In 1985, when waterborne imports are projected to rise to 10.7 million barrels/day, 53 tankers of that size would have to be unloaded each day. This increase in throughput and ship traffic could be met only through expansion of United States port capacity.

One of the key factors that will determine the changes which will be required in U.S. port facilities is the size of tankers delivering the oil. Since 1965, tanker construction has been directed almost exlusively toward vessels larger than 65,000 DWT. The development of a successful single point mooring system which allows the unloading of deep draft tankers and the closing of the Suez Canal in mid-1967 gave impetus to the construction of Very Large Crude Carriers (VLCCs) ranging from 250,000 DWT to 425,000 DWT (presently under construction. A tanker of more than 700,000 DWT has been ordered, and a 1,000,000 DWT vessel is in the preliminary planning stage.

The major attraction of large tankers is the reduction in unit transportation costs that they provide. According to Department of Commerce data, a 250,000 DWT tanker could save $0.50/ton over a 65,000 DWT tanker on the Venezuelan route (4,000 nautical miles to east coast) or as much as $2.50/ton on the Persian Gulf route (24,000 nautical miles). With the shift of primary source of imports from Latin America to the Middle East, this savings could be important for the United States.

The possible reduction in ship traffic also is obvious if larger tankers are used. By using tankers of 100,000 DWT instead of 29,000 DWT, the number of vessels that would have to be unloaded each day could be reduced from the equivalent of 53 to the equivalent of 15. By using a 200,000 DWT average, the number of unloadings required each day could be reduced to the equivalent of 7.5.

Because of the savings in transportation costs, the reduction in ship traffic, and the lack of new small tankers, it seems inevitable that the United States will be forced to use tankers larger than 100,000 DWT. The problem is that, as shown in Table IV-17, the U.S. does not have any ports capable of handling tankers larger than 100,000 DWT. The east coast,

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1/ Fact Sheet Attachment to President Nixon's Energy Message, April 18, 1973. (DWT = dead weight ton, the cargo carrying capacity in long tons, 2204 lbs.).

Table IV-17

U.S. TANKER PORTS*

Port	Maximum Vessel Size (DWT)	Port	Maximum Vessel Size (DWT)
Alaska–Nisiki	60,000	Massachusetts–Boston	50,000
California–Long Beach	100,000	New Jersey–Newark	25,000
California–Los Angeles	100,000	New York	55,000
California–Port San Louis Obispo	20,000	Pennsylvania–Philadelphia	55,000
California–San Diego	35,000	Texas–Baytown	30,000
California–San Francisco	35,000	Texas–Beaumont	80,000
Florida–Jacksonville	30,000	Texas–Brownsville	35,000
Florida–Miami	20,000	Texas–Corpus Christi	50,000
Florida–Port Everglades	35,000	Texas–Freeport	30,000
Hawaii–Honolulu	35,000	Texas–Houston	55,000
Louisiana–Baton Rouge	45,000	Texas–Port Arthur	55,000
Louisiana–New Orleans	45,000	Texas–Texas City	45,000
Maine–Portland	80,000	Virginia–Hampton Roads	50,000
Maryland–Baltimore	55,000	Washington–Seattle	45,000

* George Weber, ed., *International Petroleum Encyclopedia* (1972), p. 407

which requires the greatest amount of imported petroleum, has only one port capable of handling a tanker larger than 55,000 DWT. The study done for the Department of Commerce's Maritime Commission shows that it is neither environmentally nor economically feasible and in some cases physically not possible to dredge existing ports to the depth necessary to allow large tankers to enter.

Several potential alternatives for importing the increased quantities of petroleum were examined in the Maritime Commission's study. Some of these are: (1) lighten the loads of the VLCCs offshore of existing ports, thereby reducing the drafts of the vessels sufficiently to allow them to enter the ports and complete the unloading. (This procedure is presently being used to a limited extent in Delaware Bay and New York Bay.); (2) develop a fleet of shallow-draft large tankers which could use the present, or moderately deepened, port channels; (3) make use of conventional designs such as building a deep-draft terminal in Maine or in Lower Delaware Bay or using single point mooring systems offshore; (4) transfer the oil to the U.S. in small tankers from deepwater terminals being built in Canada and the bahamas; and (5) make use of offshore deepwater ports, serving an entire region by a transfer system of pipelines and/or feeder vessels (U.S. Dept. of Commerce).

(e) Refinery requirements

As of January 1, 1971, U.S. domestic refinery capacity (operating and operable but shut down) was 12.9 million barrels/day. The following table shows the breakdown of this capacity by PAD District. Actual crude runs in 1970 were 10.9 million barrels/day.

PAD District	Capacity (million barrels/day)
I	1.5
II	3.7
III	5.3
IV	0.4
V	2.0

Source: NPC.

In analyzing future refinery requirements, a maximum case can be identified. The maximum case would be to meet demand for petroleum products with supplies run through U.S. refineries. All imports would, therefore, be crude oil. Crude runs in 1980 would be about 20.9 million barrels/day and in 1985, 25.0 million barrels/day. This would mean an increase in crude runs of 10.0 million barrels/day by 1980 and 14.1 million barrels/day by 1985 over the actual 1970 levels.

The minimum refinery requirement would be to provide just enough capacity to process domestic production. In this case all imports would be in the

form of petroleum products and petrochemical and SNG feed stocks. Crude runs would be 11.8 million barrels/day in 1980 and 11.6 million barrels/day in 1985. Both of these figures are less than 1971 total capacity but greater than actual crude runs in 1970. The retirement of old and obsolete facilities would require the construction of some new capacity through 1985 (NPC).

Recognizing that for economic and security reasons the United States should not rely heavily on petroleum product imports, the President created incentives for the expansion and construction of refineries to process foreign crude. Under the new import system, companies building new refineries or petrochemical plants, or expanding present facilities, will be granted fee-exempt allocations of imported oil equal to 75 percent of their additional inputs for the first 5 years of operation.

Any expansion of United States refinery capacity will require capital investments. Providing the maximum refinery capacity through 1985 would require an increase in crude runs of about 14 million barrels/day. This could necessitate the construction of 15 to 16 million barrels/day of net new refinery capacity at a capital cost of about $30 million (1970 dollars). The minimum refinery case could almost be met with existing capacity. There would, however, still be significant capital requirements for the replacement of old or obsolete equipment.

(f) Balance of payments

Petroleum imports and associated activities have played an important factor in United States balance of payments. Imports of oil and refined products in recent years have equalled, in value, roughly 7 percent of all imports. The petroleum industry has accounted for approximately 25 percent of U.S. net capital outflows and 33 percent of U.S. net earnings abroad. Table IV-18 shows the balance of trade in energy fuels for 1970, 1975, and 1985. These estimates are based on the NPC Case III situation.

One of the major assumptions used by the NPC was that the f.o.b. oil prices in 1975 and 1985 will be no higher than projected 1975 prices under currently existing contracts. Factors such as devaluation of the U.S. dollar and increased competition for foreign oil probably will result in increased import prices.

Another important factor in balance of payments is the secondary trade stimulated by the purchases of petroleum. U.S. dollars which are used to purchase fuel or to finance overseas operations will generate return flows when the energy exporting country spends part of its increased income on U.S. goods and services. These return flows may come directly from the first recipient of the U.S. dollars or indirectly through third or fourth party countries. In balance of payment considerations, the direct first-round returns are most important. The level of first-round return flows from an exporting country can be estimated by the country's

Table IV-18 U.S. Balance of Trade in Energy Fuels
(dollars in billions)

	1970	1975	1985
Oil imports (delivered) 1/	-3.4	-12.9	-20.4
Natural gas and LNG imports	-0.2	-0.5	-5.3
Total energy fuels imports	-3.6	-13.4	-25.7
Oil exports	+0.5	+0.4	+0.4
Steam coal exports	+0.1	+0.2	+0.3
Metallurgical coal exports	+0.9	+1.3	+2.1
Total energy fuels exports	+1.5	+1.9	+2.8
Balance	-2.1	-11.5	-22.9

Source: NPC, pp. 298, 302.

1/ Including synthetic gas feedstocks

average propensity to import from the U.S. The propensity to import factor indicates what portion of each dollar can be expected to return in direct purchases of U.S. goods and services in the short term. Table IV-19 shows the average propensity to import from the U.S. of major oil exporting nations. It should be noted that as the primary source of imports shifts from the Western Hemisphere to the Eastern Hemisphere, the first-round return on each dollar will decrease.

(g) Security considerations

In 1970, a comprehensive study of oil imports was done by the Cabinet Task Force on Oil Import Control. The Task Force report, entitled The Oil Import Question (February 1970), identified eight major security difficulties that might attend dependence on foreign supplies:

"(1) War might possible increase our petroleum requirements beyond the ability or willingness of foreign sources to supply us.

"(2) In a prolonged conventional war, the enemy might sink the tankers needed to import oil or to carry it to market from domestic production sources such as Alaska.

"(3) Local or regional revolution, hostilities, or guerilla activities might physically interrupt foreign production or transportation.

"(4) Exporting countries might be taken over by radical governments unwilling to do business with us or our allies.

"(5) Communist countries might induce exporting countries to deny their oil to the West.

"(6) A group of exporting countries might act in concert to deny their oil to us, as occurred briefly in the wake of the 1967 Arab-Israeli War.

"(7) Exporting countries might take over the assets of American or European companies.

"(8) Exporting countries might form an effective cartel raising oil prices substantially."

With the creation of OPEC, the last point--formation of an effective cartel--has already occurred. The result, as the study had foreseen, has been a substantial increase in oil prices.

The basic problem with importing a substantial fraction of the Nation's oil is that the sources of additional foreign oil--in general, the Middl(East and North Africa--are "insecure" and might withhold oil exports to the United States for political and/or economic gain.

Table IV-19

Average Propensities to Import from the United States 1/

Algeria	0.062
Indonesia	.146
Iran 2/	.178
Iraq	.111
Kuwait	.208
Libya	.166
Nigeria	.116
Saudi Arabia	.291
United Arab Republic 2/	.221
Venezuela	.541

Source: U.S. Department of Interior, An Analysis of the Economic and Security Aspects of the Trans-Alaska Pipeline, Vol. I, p. F-8, (December 1971).

1/ Directions of trade, IMF. Averaged over trade data for 1962-1967. No clear trends were discernible, hence the recent average may be taken as an adequate approximation to the marginal propensity.

2/ A significant fraction of the trade of Iran and the U.A.R. with the United States is financed by U.S. sources. Consequently, the balance-of-payments effect of U.S. trade with both countries is reduced by partly compensatory transactions on capital account.

A study by Drs. Schurr and Homan for Resources for the Future (Middle Eastern Oil and the Western World: Prospects and Problems, 1971) notes that the question of supply interruptions

"...needs to be dealt with in the interests of both the importing and exporting countries because supply interruptions are economically damaging to both. Not only do they have sharp short-run effects which are economically painful, but their longer-run consequences can also be damaging if channels of commerce are diverted into alternatives which impose a permanent economic penalty upon both those countries that sell oil and those that buy."

However, this interdependence does not guarantee that interruptions will not occur. The study points to interruptions from the shutdown of Iranian production beginning in 1951, the closure of the Suez Canal and attendant lengthening of transportation routes in 1956-1957 and again from 1967 to the present.

The Oil Import Question identified three possible types of alternative measures to cope with an interruption of supply. These are: using synthetic sources of crude such as oil shale or tar sands; developing the shut-in capacity of Naval Petroleum Reserve No. 4; providing a means of storing oil. The potential of synthetic sources of crude oil and the NPR #4 reserves are discussed in other parts of this document. The most promising methods of storing oil are in steel tanks or in salt domes.

Estimates made in 1970 of the capital costs of storage in steel tanks range from $1.84/barrel to $2.75/barrel, including land acquisition. Annual management and repair costs would be 11 to 14 cents/barrel. Evaporation losses in a cone roof tank would be about 2 percent. However, if a floating roof were used, evaporation losses should be negligible.

In the United States, salt domes are presently used for the storage of natural gas liquids. A 1966 Bureau of Mines study indicated that there were, at that time, 130 unused onshore salt domes suitable for storage in the Gulf coast area. The Interior Department assumed a potential storage capacity of 5 million barrels at each site, yielding a total capacity of 650 million barrels. The capital cost of salt dome storage was estimated to be $1.02/barrel to $2.04/barrel. Because there is no evaporation loss and only minor maintenance and management costs, total annual costs would be low. There would be some loss of oil in the recovery process. In order to obtain the crude oil for storage, imports in the short run would have to be increased. These imports would either go directly into storage or replace domestic crude oil which would be stored.

(h) Environmental impact

The consideration of environmental impacts in this analysis primarily relates to additional ship traffic and oil handling associated with the increased level of imports. Three factors are considered in analyzing possible oil pollution related to tanker shipment of imports: (1) intentional discharge, (2) accidental discharge, and (3) casualty analysis. Such factors generally will be directly proportional to the volume of imports involved. As an alternate to geothermal development, such volumes would be small.

(1) Intentional discharge. The two primary sources of intentionally discharged oil are shoreside ballast treatment facilities and underway tank cleaning operations. Any development of ballast treatment facilities would be accomplished at the loading end of the system. It may be assumed that virtually all intentionally discharged oil in U.S. waters from this alternative will come from tank cleaning operations.

To assess fully the impact of tank cleaning operations, three separate analyses are necessary. While the overall average discharge rate in 1969-1970 was 0.074 percent of cargo, uncontrolled operations averaged 0.46 percent, load-on-top (LOT) averaged 0.027 percent, and the IMCO standard proposed in the 1969 amendments to the 1954 International Convention for the Prevention of Pollution of the Sea by Oil was 0.0067 percent (one part in 15,000). Oceanborne imports in 1975 are expected to be 4.1 million barrels/day; in 1980, 6.1 million barrels/day; and in 1985, 10.7 million barrels/day. The following table shows the expected oil spill levels under the three conditions:

Potential Oil Spill Levels (thousand barrels/day)

	Oceanborne Imports	Uncontrolled Operations	L.O.T. Operations	IMCO 1/ Standards
1975	4,100	18.9	1.1	0.3
1980	6,100	28.1	1.6	0.4
1985	10,700	49.2	2.9	0.7

(2) Accidental discharge. The 1970 Pollution Incident Reporting System (PIRS) data indicate that approximately 0.0015 percent of the oil handled in the U.S. was spilled during transfer operations (U.S. Coast Guard, 1972). Applied to the projected throughput for 1975, 1980, and 1985, this would indicate spills of 61 barrels/day, 91 barrels/day, and 160 barrels/day, respectively.

In the restricted waters surrounding harbors and ports, the 1970 experience indicates that about 0.00009 percent of the oil handled is accidentally discharged. This would indicate spills of 3.7 barrels/day in 1975, 5.5 barrels/day in 1980, and 9.6 barrels/day in 1985.

1/ International Maritime Consultive Organization.

(3) Casualty analysis. The worldwide tanker casualty analysis indicates that an insignificant amount of the total volume of oil transported is spilled, exclusive of transfer operations (U.S. Coast Guard, 1972). The environmental impact could be nominal where small spills are involved or where the spill occurs in such a manner as to have little impact on coastal or restricted water areas. By contrast, a single catastrophic incident such as the breakup of the Torrey Canyon can have disastrous results. The oil spill problem is a subject involving considerable study effort. The first report of the President's Panel on Oil Spills presents considerable details relative to the subject.

(4) Increased tankers and terminals. Increased petroleum imports will require an increase in the number and/or size of tankers. The heavily populated Northern Atlantic coastal region will be the primary destination of petroleum shipments with the Gulf coastal region being the secondary location. The west coast traffic for foreign sources would not change significantly if North Slope oil is delivered as proposed. However, there will be the increased tanker traffic associated with the movement of this oil from Alaska. Geothermal development could reduce imports to the extent shown in the introduction to this section.

If the use of conventional ports continues, tankers will generally be restricted to 60,000 DWT or less. This added congestion would increase the risk of collision and subsequent oil pollution. The transfer of oil from VLCCs to small tankers at foreign ports would also cause substantial increases in ship traffic. The problems of port congestion could be alleviated through the use of large tankers making deliveries directly to U.S. terminals.

The environmental impacts of a terminal to handle large tankers will be determined by its location. Enlarging the channels and harbors of existing ports would require dredging which could endanger sensitive estuarine areas. These areas are important as nursing grounds for many species. Extensive dredging also presents the danger of penetrating freshwater aquifers and causing saltwater contamination of a major city's water supply. Expansion of existing port facilities in populated areas could cause conflicts with existing or planned land uses.

Offshore terminals would greatly reduce the dangers of dredging and port congestion. The determining factor would be the facilities' distance from shore. Terminals which are sited closer to shore will generally require a greater amount of dredging. Such a facility could, therefore, cause some damage to estuarine areas as a result of dredging and from oil spills which could reach shore before dispersing or being cleaned up. A terminal further offshore could obviate the need for dredging and allow spills to disperse or be cleaned up before reaching sensitive areas.

The construction of a breakwater or island will permanently eliminate from productivity the area of seafloor and volume of water it occupies. Some of this loss will, however, be offset by fish havens formed by the rubble mounds and structures. A deeper offshore setting would again

be preferable because it would affect fewer species. A breakwater could reduce wave action at the shoreline and thereby reduce erosion of the beach. This could lead to the deposition of suspended sediments and accretion of the beach. Continued accretion could cause the development of a sand spit, which may ultimately extend to the offshore structure. If this accretion were located at the upper end of the beach system, the normal supply of sand would be cut off and erosion of the beach would occur.

(5) Pollution potential at loading site. The increased movement of petroleum will result in increased oil spills at the loading end. These spills will, as at the receiving end, result from intentional and accidental discharges and tanker casualties such as collisions, groundings, etc. In some exporting countries, pollution control standards may not be as stringent as U.S. standards and thus there may be a greater potential for pollution at some loading sites.

(i) Canadian export potential

The Beaufort Basin east of the Richardson Mountains and encompassing the Mackenzie Delta has considerable geologic potential for petroleum. Two discoveries of oil have been made already in this area by Imperial Oil, Ltd. They are considered to be significant, but official reserve estimates for them have not yet been published. Imperial has only indicated that it is optimistic about finding at least 2 billion barrels of recoverable crude on its Beaufort Basin leases (Oil and Gas Journal, Feb. 7, 1972, p. 4).

The Chukchi and Beaufort Seas off the northern Alaskan and northern Canadian coasts are also believed to be potential oil and gas areas. These must be considered more speculative possibilities than the onshore areas. Imperial Oil, Ltd. currently plans to built artificial islands by dredging in shallow parts of the Beaufort Sea off the Mackenzie Delta later this year. Exploratory drilling will begin from these in late 1973 (Oil and Gas Journal, Jan. 24, 1972, p. 28). Other shallow sections may be open to similar techniques. Drilling in deeper areas (50 feet or more) may, however, prove to be prohibitively expensive, even if geologic prospects are good. Hence, recoverable oil from deeper offshore areas may be limited.

There are large sedimentary areas in Canada that are favorable for the discovery of oil and gas. Recent years have seen increasing exploration activity in the Arctic islands. Results to date have indicated large discoveries of natural gas; however, discoveries of oil have not been extremely promising. Exploration has also been conducted in Canada's offshore areas in eastern Canada. The only find so far has been oil near Sable Island, which is in the southern part of Canada's offshore area and near the U.S. offshore area.

During the period from 1950 to 1969, Canada's proved crude oil reserves increased steadily from 1.2 billion barrels to 10.5 billion barrels. Since 1969, Canada's proved reserves have been slowly declining. A future increase in reserves will depend on results in the frontier areas in the Arctic and offshore. Assuming a finding rate between 1970 and 1985 comparable to that which occurred in the prior 15-year period in Canada and assuming a reserve to production ration of about 10 to 1, Canadian production in 1985 could be about 3.3 million barrels per day. If 50 percent of the production is exported to the U.S., this would amount to 1.65 million barrels per day. Canada also has high reserves of tar sands; however, with the large capital investments required, the production from this source will probably be in the range of a few hundred thousand barrels per day by 1985.

Canadian oil production is approximately in balance with Canadian oil consumption. Thus, Canadian imports of oil from the Caribbean and Middle East areas of about 50 percent of her consumption allows Canada to export about 50 percent of her production to the U.S.

Canadian oil received preferential treatment under the oil import program and thus imports from Canada increased rapidly. At the same time, Canada's oil imports from overseas areas have continued to increase so that Canada remains over 50 percent dependent on overseas imports for her internal consumption of petroleum.

The possibility of increased imports of Canadian oil into the United States is in question. For example, the Canadian Government imposed export controls on crude oil effective March 1, 1973 (The Oil Daily, February 16, 1973). Although called "temporary," they may indicate a trend toward reduced exports.

c. Oil Shale and Tar Sands

At present there is no commercial production of oil from shale or tar sands in the United States. Much research has been done and more is in progress, but no domestic process or technology has yet been developed and tested at a commercially and economically feasible production level. There is little question that large-scale production is technically possible. The related economics, however, are uncertain until additional research, development and demonstrations have been completed to the point where there is sufficient information for economic evaluation of various alternatives, and even processes within each alternative, to the point where large capital commitments can be made with reasonable confidence. It is questionable if either of these sources could be considered as feasible alternatives for significant production by 1980, but there is high probability of substantial utilization of oil shale in the following decade.

It is doubtful that shale oil can be considered a viable alternative to geothermal power production under present economic constraints. Development of oil shale solely as a substitute for geothermal power at the 298 MW and 1,000 to 2,000 MW levels would not be practical because that scale of oil shale development would be too small to be economically feasible. At the estimated level of 7,000 - 20,000 MW of geothermal capacity, the scale of substitute oil supply required would be in the order of 250,000 to 700,000 barrels per day. Under the Department of the Interior's proposed prototype oil shale leasing program, production could reach a level of 250,000 barrels per day from public lands by 1980, depending upon the success of that program. In view of the great demand for oil for other uses, such production probably could not be considered as an alternative to geothermal development until after 1985. The maximum projected oil shale capacity in the United States by 1985 could be in the order of 1,000,000 barrels of oil per day from both public and private lands.

Tar sand development as an alternative to geothermal power has less possibilities than oil shale development as there are no current known plans for major development in the United States that would represent a substitute energy supply for electric generation.

(1) Oil Shale Development

Large areas of the United States are known to contain oil shale deposits but those in the states of Colorado, Utah and Wyoming are considered to have the greatest potential for commercial shale oil production. Approximately 73 percent of the oil shale lands in those states contain nearly 80 percent of the potential shale oil and are Federally-owned. The highest grade deposits occur in an area of 17,000 square miles (11 million acres) and are capable of yielding an estimated 600 billion barrels of oil.

The President's Energy Messages of 1971 and 1973 called in part for a program for orderly development of the Nation's oil shale resources if such development can be accomplished in an environmentally acceptable manner. The

Department of the Interior currently is considering the competitive sale, in 1973, of six prototype oil shale leases on public lands, two in each of the states of Colorado, Wyoming and Utah (U.S. Department of the Interior Draft Environmental Statement for the Proposed Prototype Oil Shale Leasing Program, 1972).

Production of shale oil requires mining, crushing, and heating or retorting the rock to produce a liquid petroleum product. Some shale oil, however, has been produced experimentally by retorting the rock in place, i.e., without mining it. This technique is known as "in situ" or mining in-place and is essentially experimental in nature.

The mining of oil shale can be done by conventional underground or surface mining techniques. The technology for at least three different processes for surface retorting has been developed although none of the processes has been proven on a commercial scale. The major problem of oil shale development is the lack of a demonstration of mining and retorting on a scale sufficient to prove all the technology and to develop cost and other data necessary for determining economic feasibility and environmental acceptability.

The proposed prototype leasing program is intended to provide the opportunity for the demonstration of the economic feasibility of shale oil production and to provide the means whereby potential adverse environmental impacts can be detected and corrected before larger scale production is undertaken.

Because this program depends primarily on industry as to the timing of commercial production, it is not possible to accurately determine future production levels. However, if the maximum rate of development could be obtained, some 400,000 barrels of oil per day could be produced from public and private lands from this resource by 1980, and with additional public lands, about one million barrels per day by 1985.

It would be possible to accelerate the rate at which the necessary research, development and demonstration are accomplished by undertaking a massive direct Federal program or by offering some type of incentives or subsidies for an effort by the private sector. Under present policies substantial production could be achieved by 1985, if the proposed program is successful. From the national security standpoint, oil shale development would provide an additional major source of petroleum products within the continental United States.

The following sections discuss the mining, processing and other activities and the environmental impacts that would be associated with oil shale development in the states of Wyoming, Utah and Colorado. To the extent that oil from shale could substitute for geothermal power, the environmental impacts of geothermal development would be avoided.

(a) General - An oil shale industry, even at the prototype level, would involve very large investments and major industrial developments in currently rural areas resulting in significant environmental impacts.

Any oil shale mining and processing system must provide for the handling and disposal of large quantities of overburden material, mined rock, and the spent shale or tailings. A significant factor is that spent shale (after retorting) occupies a larger volume than the original rock in place. Methods of handling these materials are discussed in the individual mining, processing, and waste disposal sections.

The quantities of mined rock required for given levels of shale oil production and the volumes of spent shale residue are shown as follows:

Shale oil production (barrels per day)	Shale mined (million ton per year)	Volume of shale[1/] (billion cu. ft. per year) In place	After mining and retorting
50,000	27	0.4	0.6 - 0.7
150,000	82	1.2	1.7 - 2.1
550,000	301	4.5	6.0 - 7.5
1,000,000	550	8.2	1.0 - 13.8

(b) Underground mining - The room-and-pillar method of underground mining would yield a maximum of 75 percent recovery of the shale. The remainder would be left as pillars to provide for underground mine support. The ore would be raised to the surface and subsequently transported to the retort by truck or continuous conveyor belt.

Underground mining presents several different environmental effects than open pit mining. First, only 2,200 acres of surface area over a 30-year period would be affected by an underground operation for a 50,000-barrel per day plant as compared to 6,700 acres in an open pit development for a 100,000-barrel per day plant (maximum acres affected assuming no back fill). Surface restoration needs would be smaller except around shaft openings and retort facilities. Wildlife and aesthetic values would be less disturbed under this type of operation.

While this type of mining, with most of its operations underground, requires less surface area, the disposal of spent shale also must be considered. Two methods are available for spent shale disposal: (1) total surface disposal, or (2) a combination of surface disposal and return of the waste to the underground voids left by mining.

Total surface disposal would require the same amount of land as needed for open pit mining waste disposal (56 to 80 acres per year). This acreage requirement could be significantly reduced by disposal of the waste material in the mine. As spent shale occupies a greater volume than the original rock in place, only part of the waste could be returned to the mine (50 to 70 percent).

1/ Dependent upon size of material discharged from retorting system

During the initial operation, while the underground mine is being developed, all waste would temporarily be stored above ground until sufficient mined-out space for disposal was available. For the 3-year period needed to reach full capacity, the required surface disposal area would total approximately 96 acres.

Spent shale disposed in underground mines could be subject to leaching if the mine workings were flooded while active or became saturated after mining operations ceased. Environmental controls such as sealing off aquifers with concrete have proven adequate to control leaching in similar types of mining operations.

Since up to 70 percent of the waste could eventually be returned to the mine, potential dust problems, erosion, siltation, and leaching from surface piles would be reduced. The shale crushing operation would require enclosed crushing and conveyor facilities, wherever possible, and protection of the piles of crushed shale from wind and water erosion would be necessary before revegetation.

The disturbance of underground waters by mining operations, or by water used to return spent shale underground for disposal, could have an adverse effect on subsurface water quality. Because hydrologic data of much of the oil shale region are incomplete, the extent of this impact cannot be predicted at this time. Specific information which has been developed through core drilling reduces the risk of leasing areas where unavoidable adverse impacts on aquifers are likely to occur.

Close monitoring of the quality of underground waters, and the prompt action required under the proposed program to change hazardous operations, would mitigate adverse effects.

(c) Surface mine development - This type of mining involves removal and disposal of the overburden to expose the oil shale for extraction. The quantity of overburden material significantly affects the economics and timespan involved in reaching production. Current surface mining techniques, using existing large-scale equipment, could be expected to permit mine development at relatively low unit costs, although costs for environmentally adequate waste disposal and land restoration may be expected to be greater than costs for underground operations.

Where surface mining is practical, it offers the advantages of greater recovery of the resource, more efficient operations and lower unit costs, less hazardous working environment than underground mining, avoidance of subsequent subsidence problems, and the opportunity to design the resulting land surface for improved productivity and land use.

Surface mining presents significant potential environmental problems. Land required for actual mining activity for a 50,000-barrel per day operation would directly involve from 200 to 250 acres per year over a 20-year life of an operation.

During the early years of surface mine development, overburden disposal would be offsite, probably in a temporary disposal area. After 16 or more years, it would be possible to begin disposing of overburden in the pit as a part of the overall reclamation process.

A surface mine operation for a 50,000-barrel per day plant would require temporary offsite storage for up to 150 million cubic yards of overburden before pit return could begin. However, by properly selecting the disposal site and applying contouring techniques to control surface drainage, the area of land affected could be restricted to 400 acres and environmental impacts minimized.

The processed spent shale also must initially be stored in an area away from the mine site. Return of the stored, processed spent shale to the pit could begin after pit development is completed (about 16 years). Some 100 acres of land surface would be required for temporary spent shale storage.

During any open-pit mining operation, the topography will be altered and the environment changed. The actual area affected will be determined by the thickness of the overburden and oil shale, the mining plan, and the rate of development. Up to 5,000 acres could be involved, and this would be increased by about one-third if waste material were not returned to the pit. In the long term, open pits refilled with processed spent shale and overburden could be revegetated and returned for the use of wildlife and domestic grazing animals in a condition generally equal to, and in some instances better than that which originally existed.

Waste disposal areas on flat land create new "hills," which could be contoured and revegetated to prevent erosion and reduce aesthetic impacts. Canyon and gully disposal areas would gradually be converted to flat areas and revegetated.

Restoration operations would include contouring to blend with surroundings; construction of conduits, retaining dikes and terraces to prevent erosion, control surface runoff, prevent downstream contamination, and provide paths for normal water flow; protection of any natural streams; and revegetation.

Revegetation would be an integral part of watershed protection measures. It has been experimentally demonstrated that vegetation can be grown on processed oil shale with adequate seeding, fertilization and watering. A longer range vegetation goal would be the reestablishment of the natural plant community, or a suitable replacement community, to serve as wildlife food and cover. However, a significant amount of research experience needs to be accomplished before the reestablishment of the full range of native browse and cover species may be assured.

(d) Processing - Oil shale processing on the surface would require the handling of large amounts of materials. The amount of oil shale needed to support shale oil production up to 1 million barrels per day and the volume of which the shale occupies in place and after mining and retorting, have been detailed in the previous table.

A number of retorting processes have been developed worldwide for the production of oil from oil shale. Three processes that have been tested using large experimental equipment appear at this time to offer reasonable possibilities of technical and economic success if scaled up to commercial design size. They are the Gas Combustion process developed by the Bureau of Mines, the TOSCO II process of the Oil Shale Corporation, and the Union Oil Company process. In each system heat is applied to raise the temperature of crushed oil shale to about 900°F., where the solid organic material (kerogen) is converted to liquid. The equipment, method of heat application, and operation procedures differ markedly for each system.

A 50,000-barrel per day plant would be expected to occupy somewhat less than 100 acres for crushing, crushed shale storage, retorting, oil upgrading, oil storage, parking, office, and shop facilities. The retorting plant itself would require 5 to 10 acres of this total.

Offsite requirements for each plant would have an effect on the surrounding area to some degree. Access roads, power and gas transmission facilities, water lines, and oil pipelines would have to be constructed. Because only one access road would be required for each site, relatively little land would be needed for road building, although in some areas underpasses and suitable fencing might be required to reduce interference with wildlife migration patterns.

New powerlines should be constructed in accordance with the environmental criteria outlined in Rural Electrification Bulletin 61-10. Natural gaslines, if required, would be buried underground, using existing techniques for filling excavations and reseeding the right-of-way. Water supply lines would be buried, employing similar practices.

Oils from the retorting processes, with the possible exception of the TOSCO process, will require upgrading before the oil can be transported through pipelines to the final product refineries, which are expected to be located outside of the oil shale region. Modern refinery processes are suitable for subsequent upgrading. Each process also produces a retort gas that may be used within the plant as a fuel, or alternatively, to generate supplemental electrical power for nearby communities.

In the shale oil upgrading process, the principal source of contaminated water would be from steam condensed in the gas processing facilities, which would contain dissolved organic compounds. This water would be purified by conventional refinery treatment techniques and used in processed shale disposal or similar reclamation programs. The water used in the cooling tower also may contain concentrations of dissolved salts. Again, this would be conventionally treated and used in shale waste disposal.

The principal problems connected with an associated minerals extraction industry would be those concerned with solids handling in stockpiling the spent shale prior to dawsonite roasting and in disposal of the residue after alumina recovery.

No critical air pollution problems are anticipated in connection with handling and utilizing the gases produced in oil shale retorting operations. Regardless of the retorting process, gases would be coproduced with the oil product. The mixture of oil and gas products would be conducted via a closed system from the pyrolysis section of the process operation to a separation and recovery section. The mixture would be in a state varying from true vapor to mist to liquid, depending upon the particular process and its operating conditions. Treatment to recover the maximum amount of oil also would remove water and particulate matter. The remaining product gases contain small amounts of sulfur, which may or may not be economically recoverable.

Any powerplants associated with oil shale development would produce stack gases which could be sources of air pollution. Such contamination could be avoided by using the adequate emission control techniques for removal of particulate matter and by the control of sulfur and nitrous oxide emissions through the use of low sulfur fuels, combustion temperatures control, and scrubbing.

(e) <u>In situ development</u> - An <u>in situ</u> system involves the recovery of oil from the oil shale by heating it underground in its natural place. This technique has not been successfully developed or demonstrated on a large scale although considerable laboratory and field research has been carried out by government and industry.

Presently proposed heat sources for in situ recovery include underground combustion, hot natural gas, hot carbon dioxide, superheated steam, hot solvents, and combinations of two or more of these sources. It is anticipated that conduits for introducing air or heat underground would be provided by wells, mine shafts and tunnels, fractures created by a variety of techniques, or by a combination of these techniques.

Surface operations for in situ recovery would be relatively less extensive with the absence of problems associated with mining and spent shale disposal. Disturbance of the original land surface and vegetation would be minor. Earthmoving would be limited mostly to grading for well locations, plant sites, and field roads. It is anticipated that less than 10 percent of the land surface over an in situ recovery project would be affected at any one time.

The contamination of underground water could pose a problem. All presently contemplated techniques for such in situ operations involve establishing permeability by fracturing, which could change the existing hydrology, thus introducing problems.

(f) Waste disposal - The residue or spent shale resulting from surface retorting is in the form of solid particles ranging from 3 inches in diameter to a fine powder, depending on the retorting method used. It will normally be dry but may be wet if it has been processed to recover saline minerals. Extraction of saline minerals would minimize the possibility of leaching these minerals into ground water supplies. Methods of disposal will, therefore, depend on the physical characteristics of the material, its water content, and the location of the disposal area (surface or subsurface). If waste is to be returned to the mine, development plans will be affected.

In an area broken by deep gullies or arroyos, the waste could be used to fill in these depressions and generally change the landscape. Great care would be required to prevent water from eroding the waste material into main streams and rivers. If a room and pillar mining system is used, much of the waste could be returned to the mine and thereby prevent subsidence.

Improper handling of overburden or spent shale in surface disposal operations could create windblown dust or permit sediments to be carried from the waste piles by surface waters. The extent of this

problem would depend largely on the nature of the material being handled and how it is treated before or during the disposal process. At present, either wetting spent shale piles followed by compaction and revegetation, or disposal as a slurry followed by dewatering would appear to be the most feasible methods for controlling dust and sedimentation.

The rate of waste buildup on a typical 22-acre disposal site from a 50,000-barrel per day plant (approximately 250 feet per year) would far exceed the buildup of soil moisture from a low annual precipitation of 1 to 2 feet. Because of this, the water from precipitation would not saturate the waste material during the emplacement process. To prevent future ground water contamination, however, it may be necessary to construct an impermeable floor over the area where the waste material is to be deposited. This barrier would prevent the leach waters from entering underground water systems and would direct percolating waters toward the impoundment dams where they could be controlled for treatment, evaporation, or use. However, mineral leaching by water percolating through the waste piles is not anticipated to be a significant problem since compacted and moistened retorted shale has been shown in experimental tests to be of low water permeability. Natural cementation also takes place over relatively short time periods, particularly when the spent shale has been moistened and compacted, tending to minimize surface leaching and erosion.

Design concepts for controlling sediment problems may include canals and culverts to carry runoff water around and/or under the disposal site. Protection against flash floods, if common to an area, could be provided by upstream dams and canals that would divert storm runoff from the waste pile. Retaining dikes and terraces could be used to reduce the sediment yield to the streams to an amount less than the same areas contribute under natural conditions.

Shale oil would be moved to refinery centers via connecting pipelines from the sites to existing transcontinental pipelines. These 10 to 12-inch connecting lines could be constructed in some cases using existing rights-of-way to ensure minimum surface disturbance, with appropriate vegetation and positive maintenance to prevent leakage. The pipelines would avoid major earthquake regions; maintenance would be reduced because of lesser opportunity for breaks caused by natural disasters.

The extent of impacts from oil losses, should an incident occur, on habitat and associated wildlife and fish populations would depend on numerous factors, including volume of oil lost, leak location, and weather conditions, the quantity and quality of wildlife and fish habitat affected, timing with respect to organism life history stages, and effectiveness of contingency plans. The most significant impacts would be on aquatic organisms and water-related birds and mammals.

Such impacts would be minimized by building oil handling facilities and routing pipelines to avoid the more vulnerable habitats.

Construction of the pipelines, together with the accompanying service roads, would cause disruption of the vegetation patterns in a semi-arid region, but revegetation of the construction zone and maintenance of the service roads should minimize any adverse effects of this construction. Construction of service roads would provide public access to presently little-used areas and will place pressure on wildlife.

(g) Other impacts - One of the greatest possible impacts would be the requirement for large amounts of water required for retort plants and the disposal of waste water. From 121,000 to 187,000 acre-feet annually would be required for 1 million barrels per day of shale oil production.

In addition, as much as 10 gallons of water per ton of shale could be produced in the surface retorts. This water could contain dissolved saline and organic compounds. It could be used to moisten the waste shale to prevent dust problems. However, it would require treatment prior to other uses to remove hydrocarbons and malodorous compounds, and perhaps dissolved minerals.

Large quantities of natural ground water (perhaps 25 million acre-feet) occur in leached zones of the deep oil shale areas, but the location, composition and movement of such waters have yet to be defined in many areas. These aquifers may contribute substantially to the overall water supply available to satisfy requirements for oil shale development.

Use of ground water in oil shale development could decrease the natural discharge of springs and seeps. This could result in adverse effects on associated vegetation, and any fish or wildlife dependent on that water supply. Careful lease site selections to avoid natural water features which provide aquatic habitat and/or development of alternate water sources for wildlife would prevent or mitigate such effects.

Degradation of water quality could occur from discharge of product or waste waters, siltation of streams, or leaching of saline minerals from spent shale. It could be avoided in most cases by proper design, equipment, and adequate supervision and monitoring of operations. Leaching of spent shale would not be expected to be a problem because properly emplaced waste sites will harden through natural cementation.

In addition to these waters, there would possibly be a water slurry produced by a wet scrubbing process used to remove fine dust in gas streams. The slurry from the wet scrubbing could be used to wet the spent shale.

Water would also be used in the cooling phase of the process, but the amount needed could be kept to a minimum by employing air cooling. Any "sour" water streams produced by accidental contact with oil in

final water condensers would be treated by conventional oil refinery methods.

The nature of the foreseeable problems associated with water quality would depend largely upon the mineral characteristics of the processed shale and the method of disposal. The foreseeable problems, as outlined, are believed controllable with present technology.

The principal sources of potential air pollution in an oil shale development would be solid particulates resulting from mining and spent shale disposal operations, dust produced during crushing and retorting operations, process stack gases from retorting, refinery by-product gases from shale oil upgrading, and any gases from electric generating plants or similar processes.

Potential dusting from surface waste disposal piles, mentioned previously, would be prevented by moistening the material and using disposal and revegetation techniques already under development in field tests. If residue shale were transported in dry form, covered conveyors may be required.

Certain areas of the oil shale region provide a habitat with an attractive combination of vegetation, climatic, physiographic, and cultural conditions for nearly 300 species of wildlife. Fishery habitat is limited and inhabited principally by nongame fish populations.

Probable and potential impacts on wildlife and fish are of two general types: localized impacts at, and in the vicinity of, the actual oil shale operations and impacts resulting from ancillary urbanization and human pressures.

Construction and operation would have varying degrees of direct and indirect impacts upon fish and wildlife and their habitat in the immediate vicinity of mining plants and along their appurtenant roads, surface facilities, and pipelines. The impacts would include such things as alteration of wildlife behavior and activity patterns; removal and reduction of food and cover through removal of overburden and surface vegetation for mining, roads, plants, etc.; and wildlife disturbance from noise of mining and industrial operations.

Aquatic habitat is very small in the oil shale areas. However, were an oil shale operation established within the vicinity of such habitat and changes in the quality of local surface or ground water were to occur, there could be impacts on fish populations. Additionally, if use of ground water for development and operation caused a lowering of natural ground water discharges, such as springs and seeps, potential adverse impacts on associated ecological features would result. In that event, supplemental habitat water development programs such as wells and reservoirs would be required.

Certain species, such as mountain lion, bear, elk, and mule deer are by nature incapable of adjusting to the aggregate of human activities

in a developing area (i.e., urban expansion, waste disposal, additional recreation use, etc.). Although populations of these species in the oil shale areas could be expected to decline over time as a result of oil shale production and population pressures, they should not decrease to the extent that any species would become rare, endangered or extinct. Added hunting and angling pressures indirectly resulting from improved access and increased local population could reduce the hunting and angling quality for some species.

The oil shale lands in Colorado, Utah, and Wyoming are located in a sparsely settled, semiarid to arid region of moderately high elevation. The oil shale areas are now used primarily for livestock grazing, agriculture, or recreation; therefore, some changes in land use patterns would result with development.

Development of public oil shale lands would have little direct impact on agricultural activities, since most agricultural lands are privately owned. However, some impact could occur if oil shale activities jeopardized water resources traditionally used for irrigation purposes.

The magnitude of the impact that oil shale operations could have on the region's aesthetic, cultural, and recreational qualities would depend on the location of the site, its size, and the system of extraction and processing as well as the operating practices followed. The oil shale area is generally remote, although little of it can be considered true wilderness. Present access, ranching, mineral extraction activities, and recreational use (principally hunting) would seem to preclude that terminology. "Primitive" may be an appropriate term.

Some stretches of the Green River may qualify as either a wild or scenic river under terms of the Wild and Scenic Rivers Act of 1968. A section of the Green River in Utah is a designated Historic Site.

(2) Tar Sands

Tar sands and bituminous sands are terms used to describe hydrocarbon-bearing deposits distinguished from more conventional oil and gas reservoirs by the high viscosity of the hydrocarbon, which is not recoverable in its natural state through a well by ordinary oil and gas producing methods. Reservoir energy is typically nonexistent, or minimal, so that for production to be initiated and sustained some form of energy (heat, fluid pressure, mechanical work by mining machinery, etc.) must be applied.

Many such deposits are known, but only a few are likely to become of major commercial interest to North America, and to the United States in particular, in the next 15 to 30 years. Chief among these few are the Athabasca deposit in northern Alberta, Canada, and the Orinoco deposits in eastern Venezuela (National Petroleum Council, 1971). The

National Petroleum Council's (NPC) Study on the U.S. Energy Outlook (1971) for the period 1971-1985 considered only deposits with tar sand resources of 0.5 billion barrels or more to be worth evaluating as potential sources likely to affect the United States energy supply. Only five such deposits were identified in the United States. These five deposits, all in the State of Utah, are estimated to contain a total of about 17-27.6 billion barrels of tar sand resources in place, based on outcrop data and a relatively few drill-hole observations. Therefore, the NPC study concluded that domestic tar sand resources are unlikely to have an important role in the United States energy supply through 1985.

The following factors will probably deter early development of the Utah deposits (NPC study 1971; Ritzma, 1969, 1970).

The Tar Sand Triangle and Circle Cliffs deposits are largely on Federal lands. Leasing of Federal lands for asphaltic minerals or tar sands has been delayed pending legislative action.

Proposals for national parks, national monuments, desert wilderness areas, and recreation areas cover most of the Circle Cliffs and Tar Sand Triangle deposits and could result in surface use incompatible with mineral resource development.

Lack of suitable water supply may constitute a serious handicap to exploitation of the Utah deposits.

Most Utah deposits are not susceptible to mining, but more likely will be developed by in situ methods, the technology for which has yet to be perfected.

While resource estimates have been made for the Utah deposits, no estimates are available as to the potential reserves recoverable. The recovery by in situ methods is estimated to be only in the order of 35-50 percent of the resource in place.

The initial development of tar sand production technology has been in the Athabasca region of Canada since it is there that the largest and most accessible tar sand deposits occur. The National Petroleum Council (1971) estimates that 174 billion barrels may be economically recoverable; the Alberta Oil and Gas Conservation Board's estimates are even higher. Others have estimated that as few as 85 billion barrels are currently minable (Schurr and Homan, 1970). No United States deposits are as rich as those of Athabasca.

The difficulty of the tar sand extraction process has caused this synthetic crude oil to be more expensive than crude oil from conventional sources. Recently, however, Great Canadian Oil Sands, Limited, in Alberta, Canada, has enjoyed sufficient success to suggest that tar sands could become competitive and Syncrude Canada, Limited, has applied for expansion of capacity (Syncrude, 1971).

Although a decision by the Canadian Government to accelerate the exploitation of tar sand potential might significantly increase Canada's crude oil production and exporting potential by 1985, it is unlikely because of existing economic conditions that development of the tar sand deposits of the United States will begin or contribute significantly to domestic supply by 1985. (Canadian production is currently limited by licensing requirements in addition to the technical factors.)

The NPC study (1971), based on experience in tar sand mining in Canada, reached the following conclusions with respect to production of strip-mining methods: "The mining-extraction route is most applicable to the shallow deposits (up to 100 or 150 feet of overburden). Because the bitumen content of average sand is normally less than about 12 percent by weight, an immense tonnage of sand and overburden must be moved, using strip-mining methods, to support an economically large synthetic crude output. The ratio is about 2.4 tons of sand and 1.0 ton of overburden, more or less, per barrel of synthetic crude oil. An overall average utilization of total tar sands in a mining leasehold may be on the order of 75 percent."

Strip mining offers the highest recovery rates and most economic return per unit area subjected to exploitation but causes maximum disturbance of surface area subjected to exploitation. Few large United States deposits will be susceptible to strip-mining methods because of the thickness of overburden. Material filed by Syncrude of Canada in support of its application in Canada (Syncrude, 1971) for amendment of its license to produce additional oil from tar sands provides some indication of the nature of operations and their impact on the environment. These impacts are somewhat analogous to those of producing oil from oil shale (U. S. Department of the Interior, 1972).

Overburden would have to be removed and stored temporarily until excavation had advanced far enough to permit its replacement in the mining pit. (Syncrude anticipates only 33 feet of overburden and low-bitumen reject sands--less than for many possible oil shale operations --so that the extent of overburden problems would be limited.) Production of 125,000 barrels per day for 13 years would be from an area of 5.5 square miles. Surface facilities for extraction of the bitumen would require about 200 acres of land.

Plans for using underground mining methods and techniques for the development of tar sand resources as an energy source are unknown at this time. In situ methods will more likely be used for recovery from deposits at depths not susceptible to strip mining as many tar sands are not well cemented and would tend to slump or cave if underground mining methods were used.

At present there is no commercial-scale technology available for in situ recovery of tar sand resources, although this method is being tested in a pilot plant stage. This method holds greatest promise for recovery of United States deposits.

The NPC's 1971 study reached the following conclusions with respect to in situ methods:

> "The two methods most thoroughly researched and tested in the field involve (1) injecting steam plus an emulsifying agent (e.g., caustic soda as used in a Shell Oil Co. trial) into the deposit and (2) using thermal-recovery or 'fire-flooding' techniques as experimented with by Amoco (Canada) and others. For either method to succeed, communication must be established down-hole in the formation between the injection wells and the production wells. Field tests have determined that this can be achieved. Overall recovery of in-place bitumen via either in situ technique is estimated to be on the order of 35 to 50 percent, distinctly lower than the corresponding value for mining extraction."

In situ processing would result in minimum surface disturbance. Well locations would utilize only a small percentage of the surface. There would be no sand tailings and resultant disposal problem. However, recovery rates are lower than that achieved by strip mining and, therefore, greater areas would have to be subjected to development in order to achieve the same volume of production. Accordingly, much of the resource potential would be lost by this technique.

Many of the various potential environmental impacts associated with the mining of oil shale as outlined in the preceding section would be similarly applicable to tar sand mining.

The NPC study of 1971 gives the following analysis of processing of the bitumen from tar sands, based on current operations by Great Canadian Oil Sands, Ltd. (GCOS) and plans by Syncrude Canada, Ltd., for upgrading the Athabasca tar sand deposits to a synthetic crude oil suitable for pipeline distribution.

> "Upgrading of bitumen to synthetic crude suitable for shipment to refining-marketing centers for manufacture into finished products involves hydrogen-enrichment of the bitumen by some means. Also, for a fuel-balanced operation, necessary in the remote locale of major tar sands deposits, sufficient bitumen or components thereof must be set aside as fuel for the operation, and for production of hydrogen. These requirements result in a synthetic crude product/bitumen volume ratio of from about 0.78 (GCOS, via coking and hydrogenation of coker distillates) to 0.87 (Syncrude, via hydrovisbreaking plus hydrogenation of visbreaker distillates). Presumably in situ bitumen would be upgraded in about the same ratio to make a similar synthetic crude."

Commercial-scale processing methods for substantial reserves of tar sands in Canada have now been developed. These methods may be directly applicable to processing of United States deposits, if and when they are developed, without extensive pilot-plant operation. The coke from the upgrading process is recycled as a fuel for the refining operation and not left as a waste product.

Prerefining by hydrogen enrichment of tar sands in Canada has resulted in a superior feedstock for pipeline shipment to refining. Both the Canadian and the United States deposits in Utah are advantageously located to nearby existing pipeline facilities.

According to Cameron (1969), "Present production from the GCOS plant is moving primarily to the Great Lakes area, some into the United States. The oil will have traveled 1,925 pipeline miles to its destination in Sarnia, Ontario."

Coke obtained from processing is utilized in Canada as a fuel for the refining operation. Sulfur could also be recovered as a byproduct. Initial plans by GCOS were to recover 45,000 barrels of synthetic crude oil, 3,000 tons of coke, and 300 tons of sulfur a day. According to the 1971 NPC study, "In the process of hydrogen-enrichment, the sulfur and nitrogen contents are reduced to tolerable levels via hydrogenation and the metals exit with the carbon residue . . . ."

On a unit basis there are about 3.0 tons of waste material (2.0 tons of sand and 1.0 ton of overburden) more or less per barrel of synthetic crude oil produced using strip-mining methods in the Athabasca area currently under development. Waste associated with tar sand extraction would include sand tailings, overburden, coke, sludge, sulfur dioxide emissions, nitrogen and metals; however, if in situ technology is perfected, the waste disposal problems associated with stip mining will be eliminated.

The tailings (sand from which most of the bitumen has been removed) are, in the Syncrude operation, initially deposited in a diked area (retention pond, 9.32 square miles) to prevent contamination of water supplies by runoff. Subsequent tailings would be returned to the mined area. The extraction process uses water and produces an oily sludge as a byproduct. The Syncrude process places the sludge in the manmade tailings pond; failure to make suitable provision for disposal of sludge and tailings could lead to contamination of water supplies.

d. Natural Gas

At the three projected levels of geothermal development considered herein, gas alternatives would be as follows:

Geothermal capacity (MW)	Gas equivalent per year (trillion Btu)	(billion cu.ft.)
298	8	8
1,000 - 2,000	27 - 54	26 - 52
7,000 - 20,000	190 - 540	184 - 524

Natural gas is a premium fuel as it is clean burning, convenient to transport and use, and has the least detrimental environmental effects. Natural gas provides one-third of the Nation's energy requirements. Residential, commercial, and industrial consumers depend on it for approximately one-half of their energy needs, and one-fourth of the requirements of steam-electric plants is supplied by natural gas.

The emphasis being placed on improving air quality will further accentuate demand for natural gas because its exhaust contains no sulfur and no particulates. During recent years, demand for natural gas has exceeded the growth rate of demand for total energy; energy demand has increased at an annual average rate of 5.1 percent whereas natural gas demand increased 6.1 percent annually.

Currently gas is the major fuel used for generating electricity in California, where it accounts for three-fourths of the steam-electric generation. Major electric plants use natural gas on an "as available" basis, shifting quickly to fuel oil during periods of peak gas demand. However, in view of the expected high future demand for gas for other uses, it is not expected that fossil fuel additions to steam generating capacity on the west coast will use scarce gas supplies but will rely instead on low-sulfur content fuel oil. The projected annual gas demand for electricity in PAD District V (embracing California, Oregon, Washington, Nevada, Arizona, Alaska, and Hawaii) has been estimated to be 1,050 trillion Btu (TBtu) for 1975, 1,147 TBtu for 1980, and 1,315 TBtu for 1985 (National Petroleum Council, 1971). However, during the same periods of time, the shortfall in demand over supply has been estimated to be 980 TBtu in 1975; 1,510 TBtu in 1980; and 2,240 TBtu in 1985. With an estimated constant supply of some 54 TBtu geothermal resource potential during these same periods, it would appear that gas is not a feasible alternative in that there will not be enough gas to supply the demand, let alone serve as an alternative for geothermal resources. Geothermal resources could serve to supplement the shortfall in gas, particularly in the category where gas is used for producing electricity.

In the event that sufficient gas were available as a substitute for geothermal power, the environmental impacts would be somewhat similar. Both sources require drilling to tap energy reservoirs, construction of pipelines, electric powerplants, and transmission lines. Both have minimal air quality impact, and water quality impacts are controllable with currently available technology. A major difference is that geothermal powerplants must be located close to the heat source while gas can be transported great distances in pipelines. Normally, gas-fired electric generating stations are sited close to load centers to minimize electrical system distribution losses while geothermal power must be transmitted over powerlines to the point of energy use.

While demand for natural gas has been increasing at rates greater than any other primary fuel, total domestic proved reserves of natural gas now available to markets have been declining since 1967. The cumulative demand for natural gas during the period 1964 through 1970, inclusive, amounted to 126 trillion cubic feet, an average of 18 trillion cubic feet per year. However, during this time, the reported proved reserve additions, excluding Alaskan North Slope reserves, increased at an average yearly rate of less than 17 trillion cubic feet. Thus, the inventory of proved reserves has been diminishing by over 1 trillion cubic feet per year.

The relatively low price of natural gas has not only stimulated the rapid use and decline of natural gas supplies but, along with inflated costs, it has diminished incentives to search for and develop new natural gas deposits. Total proved reserves of natural gas as of the end of 1970 were 291 trillion cubic feet. Estimates of reserve additions between 1971 and 1985 in the conterminous states would total 141 trillion cubic feet. The significance of the ratio of proved reserves to annual domestic production (RIP) is important. After World War II, the RIP rate exceeded 30 to 1; by 1964, it had declined to 18 to 1; and in 1970, to 14 to 1. It is not clear as to what the minimum tolerable RIP ratio should be, but based on industry experience, a RIP of 10 appears to be the minimum that could be tolerated without significant and recurrent curtailment in services.

Several possible ways of increasing or supplementing present gas reserves are:

1. Increase the price of natural gas
2. Nuclear stimulation of known reservoirs
3. Increase foreign imports of pipeline gas and liquefied natural gas.
4. Synthetic gas from coal and oil

(1) Increase the Price of Natural Gas

The amount of undiscovered domestic natural gas resources recoverable with current technology, estimated by both Government and industry, exceeds the estimated cumulative demands for natural gas through this century. The U.S. Geological Survey has estimated that there are approximately 2,100 trillion cubic feet of undiscovered natural gas resources recoverable under current technology. About 40 percent of this quantity is located offshore. Such resources, however, will be translated into supplies at meaningful rates only when economic incentives motivate the industry to allocate capital for exploration and development efforts. Table IV-20 indicates the sources of gaseous fuels considered feasible between 1971 and 2000.

In 1971, domestic supply accounted for 96 percent of total U.S. supply with imports accounting for only 4 percent. In 2000, the forecast indicates that our gaseous fuel supply will have the following composition:

Domestic supply	
Domestic natural gas	57.9 percent
Synthetic gas	13.9
Subtotal	71.8
Gas imports	
Pipeline imports	19.3
Liquefied natural gas	8.9
Subtotal	28.2 percent

Thus, by 2000, imports could account for 28.2 percent of our total supply of gaseous fuels. It is expected that the bulk of the pipeline imports will be from Canada. Prices paid for such supplies are likely to result in substantial increases in prices for domestic gas supplies; this in turn should accelerate exploration for new domestic gas supplies.

It is implicitly assumed that price increases sufficient to elicit the additional domestic supplies forecast will be forthcoming and that these price increases will make supplemental supplies of LNG and synthetic gas economically feasible in some locations. Production of the synthetic gas from coal is dependent on making the mining of coal (principally strip mining) environmentally acceptable. The alternative to not producing this synthetic gas from coal is heavier dependence on petroleum and petroleum products.

The estimates of the Denver Research Institute's Future Requirements Committee (FRC, 1971) provide an upper bound on gas consumption since they assume supplies adequate to meet all estimated requirements, current costs, evolutionary technological development, and no major war, depression, or other catastrophe. The critical assumption here is that supplies will continue to be available at current costs.

Table IV-20

Estimated gaseous fuel supply schedule, 1971 actual with projections to the year 2000

Gaseous Fuel supply	1971	1975	1980	1985	2000
Total Supply:					
Billion cubic feet	22,050	24,462	26,869	29,537	38,459
Trillion Btu	22,734	25,220	27,680	30,390	39,480
Domestic Supply:					
Domestic Natural Gas 1/					
Billion cubic feet	21,150	21,962	22,269	21,837	22,159
Trillion Btu 2/	21,810	22,640	22,960	22,510	22,850
Synthetic Gas					
Billion cubic feet	-----	-----	700	2,000	5,500
Trillion Btu 3/	-----	-----	700	2,000	5,500
Total Domestic Supply					
Billion cubic feet	21,150	21,962	22,969	23,837	27,659
Trillion Btu	21,810	22,640	23,660	24,510	28,350
Gas Imports:					
Pipeline Imports 4/					
Billion cubic feet	900	2,000	3,000	4,100	7,400
Trillion Btu 2/	924	2,060	3,090	4,230	7,630
Liquefied Natural Gas					
Billion cubic feet	-----	500	900	1,600	3,400
Trillion Btu 2/	-----	520	930	1,650	3,500
Total Imports					
Billion cubic feet	900	2,500	3,900	5,700	10,800
Trillion Btu	924	2,580	4,020	5,880	11,130
Percent of total	4.0	10.2	14.5	19.3	28.2

1/ Includes Alaska.
2/ Converted on basis of 1,031 Btu per cubic feet.
3/ Converted on basis of 1,000 Btu per cubic feet.
4/ Includes Canada and Mexico.

Source: United States Energy Through The Year 2000, Interior, 1972 (Dupree and West)

The lowest projections, in contrast, are those of the National Petroleum Council's new "Case IV" (NPC, 1972), which assumes continuation of present trends, i.e., restrained prices for domestic oil and gas, the current regulatory climate, and continued difficulty in reconciling energy and environmental imperatives. In all cases, including Case IV, the NPC projects a price rise. (The NPC examines four cases in all. Case I, the most optimistic, "requires a vigorous effort fostered by early resolution of controversies about environmental issues, ready availability of government land for energy resource development, adequate economic incentives, and a higher degree of success in locating currently undiscovered resources than has been the case in the past decade." Cases II and III are intermediate assumptions. Note, however, that even the NPC's estimate of domestic production in its most optimistic case does not equal the "demand" derived by the Future Requirements Committee.)

In between the two extremes fall the projections of the Federal Power Commission staff (FPC, 1972) and the latest projection by the Department of the Interior (Dupree and West, 1972). The Federal Power Commission staff projections in effect assume continuation of policies current as of February 1972, although their assumptions concerning price are not reported. The FPC report is particularly valuable in that it describes in detail the projections of sources of gas and allocates production estimates by region. Note that this projection is somewhat more optimistic than the NPC estimate of the outcome of current trends; it in effect assumes an enlightened FPC policy and, perhaps, a measure of good luck.

Finally, the most recent projection by an Interior group (Dupree and West, 1972) takes a middle ground, assuming that "inflationary trends will raise the nominal prices of all fuels but ... fuel prices, in general, will rise faster than other commodity prices .... Natural gas prices will rise fastest, eliciting the supplies forecast." The extent of this rise, and whether it would necessitate deregulation, is not stated. (See Table IV-21)

The sale of natural gas for resale in interstate commerce is currently under Federal Power Commission jurisdiction. In 1954, the Supreme Court ruled that independent producers of natural gas, whose sale of gas goes into interstate commerce, were not exempted from regulations under the Natural Gas Act.

Although in the past few years the FPC has modified its pricing policies to be more responsive to the gas supply situation, the FPC Chairman, on April 10, 1973, urged Congressional action to amend the Natural Gas Act to decontrol the price of new gas supplies. The President, in his Energy Message to Congress April 18, 1973, proposed such action, stating:

"For more than a decade the prices of natural gas supplies to pipelines under this extended regulation have been kept artificially low. As a result, demand has been artificially stimulated, but the exploration

Table IV-21

ESTIMATES OF U.S. CONSUMPTION OF GAS 1/*
Quadrillion (10^{15}) BTU Per year 2/

Date	Source	Ref.*	1975	1980	1985	1990	2000
4-70	SRI	(a)	23.8	29.9	-	-	-
4-70	EBASCO	(b)	26.0	30.4	35.0	-	-
10-70	Morrison	(c)	-	27.2	-	35.0	41.7
2-71	Darnstadter	(f)	-	27.3	-	35.0	47.1
6?-71	Oil Co. #4	(g)	-	28.4	-	-	46.0
6-71	USDI	(h)	28.7	-	39.4	-	50.6
7-71	NPC (Supply) 3/	(i)	22.4	22.5	22.2	-	-
9-71	Starr	(j)	-	26.0	-	-	-
10-71	FRC	5/	33.9	38.5	43.6	50.1	-
?-71	USBM	(k)					
	Low		-	-	-	-	35.9
	Forecast base		-	-	-	-	40.4
	High		-	-	-	-	57.5
?-71	AGA	4/	25.8	32.3	40.3	49.7	-
?-71	Schurr	(n)	-	27.5	-	-	-
?-71	Steele	(o)	-	30.6	-	-	-
1-72	USDI	(h)	28.7 6/	-	39.4 6/	-	50.6
2-72	FPC	7/	27.0	25.8	26.9	30.2	-
2-72	Morrison	(p)	-	-	-	-	41.0 6/
6-72	Chase	(q)	-	-	27.2 8/	-	-
11-72	USDI	(r)	22.2	27.0	28.4	-	34.0
12-72	NPC						
	Case I	(t)	25.7	31.4	41.1	-	-
	Case II	(t)	25.5	29.4	35.5	-	-
	Case III	(t)	24.0	25.4	29.5	-	-
	Case IV	(t)	23.6	22.0	22.6	-	-
	Compound growth relative to 1971 actual consumption of 22.7 TCF, at alternative rates of:						
	0%		22.7	22.7	22.7	22.7	22.7
	3%		25.6	29.7	34.4	39.9	53.6
	4%		26.6	32.7	40.1	49.3	74.4
	5%		27.6	35.3	45.0	57.4	93.6
	6%		28.7	38.4	51.4	68.8	123.0

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* See notes and references on following pages.

Notes to Table IV-21

1/ Actual consumption in 1971 was 22.734 Q. *

2/ Natural gas usually contains 1,032 Btu/cu.ft. Therefore, 1 Q is approximately equal to 1 trillion cubic feet (TCF).

3/ The NPC uses the projections of potential demand made by the Future Requirements Committee (DRI); these data reflect no consideration of gas supply limitations or relative changes in the energy pricing structure. The NPC projections of available supply (including imports) are considered to be demand-limiting elsewhere in the NPC report.

4/ American Gas Association (AGA), 1971, Department of Statistics, "Gas Utility and Pipeline Industry Projections 1969-73, 1975, 1980, 1985, and 1990."

5/ Future Requirements Committee (FRC), Future Requirements Agency, Denver Research Institute, 1971, "Future Gas Requirements of the United States," vol. 4, October 1971.

6/ Republication of earlier estimate.

7/ (FPC, 1972); converted from volume at 1,032 Btu/cu.ft.

8/ Converted from 12,830,000 barrel/day equivalent, assuming 5,800,000 Btu/bbl.

* Actual consumption in 1972 was 23.308 Q (USBM, 1973).

References to Table IV-21

(a) SRI-70: Requirements for southern Louisiana natural gas throuh 1980: Exhibit in FPC docket No. AR69-1, Stanford Research Institute, April, 1970.

(b) EBASCO-70: Energy consumption and supply trends chart book, April 1970: EBASCO Services Inc.

(c) Morrison-70: "Energy Resources and National Strength" by Warren E. Morrison: Auditorium presentation, Industrial College of the Armed Forces, Washington, D.C., October 6, 1970 (transcript of lecture and statistical appendix).

(f) Darnstadter, Joel, 1971, "Trends and Patterns in U.S. and Worldwide Energy Consumption--a background review," Resources for Future Inc., February 1971 (available in draft. Scheduled to be published in 1972 as appendix to papers presented at RFF Forum on Energy, Economic Growth and the Environment, April 20-21, 1971, Washington, D.C.).

(g) Oral presentations to the Department of the Interior, June-July 1971, cited by Office of Oil and Gas in an informal compilation, July 16, 1971.

(h) U.S.D.I., Preliminary estimates of Bureau of Mines Staff, appended to statement of the Honorable Rogers C.B. Morton, Secretary of the Interior, before the Committee on Interior and Insular Affairs, United States Senate, June 15, 1971. Also presented in U.S.D.I., "United States Energy: A Summary Review," January 1972, p. 20.

(i) National Petroleum Council, "U.S. Energy Outlook: An Initial Appraisal, 1971-1985," Vol. I, July 15, 1971.

(j) Starr, Chauncey, "Energy and Power," Scientific American, vol. 225, no. 3 (September 1971), p. 39. (Estimates of charted values.)

(k) U.S. Bureau of Mines, Mineral Facts and Problems, 1970 Edition, Bulletin 650, Washington, 1970 (table 4, pp. 17-18).

(n) Schurr, Sam H. and Paul T. Homan, Middle Eastern Oil and the Western World, New York, American Elsevier, 1971.

(p) Morrison, Warren E., "Impacts of Alternative Energy Systems," Proceedings of the Council of Economics of the A.I.M.E., San Francisco, California, February 20-24, 1972, pp. 147-178.

(q) The Chase Manhattan Bank, Energy Economics Division, "Outlook for Energy in the United States to 1985," June 1972.

(r) DuPree, Walter G., Jr. and James A. West (U.S.D.I.), "United States Energy Through the Year 2000," December 1972.

(t) National Petroleum Council (NPC), "U.S. Energy Outlook: A Summary Report of the National Petroleum Council," Washington, December 1972.

and development required to provide new supplies to satisfy this increasing demand have been allowed to wither. This form of government regulation has contributed heavily to the scarcity we now anticipate.

"As a result of its low regulated price, more than 50 percent of our natural gas is consumed by industrial users and utilities, many of which might otherwise be using coal or oil. While homeowners are being forced to turn away from natural gas and toward more expensive fuels, unnecessarily large quantities of natural gas are being used by industry.

"Furthermore, because prices within producing States are often higher than the interstate prices established by the Federal Power Commission, most newly discovered and newly produced natural gas does not enter interstate pipelines. Potential consumers in non-producing States thus suffer the worst shortages. While the Federal Power Commission has tried to alleviate these problems, the regulatory framework and attendant judicial constraints inhibit the ability of the Commission to respond adequately.

"It is clear that the price paid to producers for natural gas in interstate trade must increase if there is to be the needed incentive for increasing supply and reducing inefficient usage. Some have suggested additional regulation to provide new incentives, but we have already seen the pitfalls in this approach. We must regulate less, not more. At the same time, we cannot remove all natural gas regulations without greatly inflating the price of gas currently in production and generating windfall profits.

"To resolve this issue, I am proposing that gas from new wells, gas newly-dedicated to interstate markets, and the continuing production of natural gas from expired contracts should no longer be subject to price regulation at the wellhead. Enactment of this legislation should stimulate new exploration and development. At the same time, because increased prices on new unregulated gas would be averaged in with the prices for gas that is still regulated, the consumer should be protected against precipitous cost increases.

"To add further consumer protection against unjustified price increases, I propose that the Secretary of the Interior be given authority to impose a ceiling on the price of new natural gas when circumstances warrant. Before exercising this power, the Secretary would consider the cost of alternative domestic fuels, taking into account the superiority of natural gas from an environmental standpoint. He would also consider the importance of encouraging production and more efficient use of natural gas."

Concurrent with the President's Energy Message, proposed legislation was submitted to Congress to amend the Natural Gas Act. Until such legislation is passed by Congress, however, the wellhead price of new gas will continue to be regulated by the Federal Power Commission.

Deregulation of the price of new gas is a policy option which, if implemented, should stimulate the economic incentive for the discovery of new supplies and reduce inefficient use of the fuel. When prices go up, producers will find greater opportunity for profit in developing resources which under present pricing levels and policies might seem too risky or uneconomical to develop. On the other hand, consumers will be less willing to pay higher prices and may curtail some uses of the fuel, tending to bring supply and demand into balance.

A thorough analysis of the environmental impact of deregulation of the wellhead price of gas is currently in process at the Department of the Interior. In the interim, it should be noted that this alternative would not result directly in any specific action. It would, however, trigger market forces which would result in increased activities impacting on the environment. These activities would center on increased domestic production both onshore and offshore of natural gas and associated oil. Discussion of the impact of these activities is contained in the alternatives of increasing onshore and offshore oil and gas production.

(2) Nuclear Stimulation of Known Reservoirs

Nuclear stimulation by fracturing low permeability gas reservoirs otherwise incapable of sustaining commercial production may have potential to add materially to U.S. recoverable gas reserves. However, it may be a controversial method as there appears to be many built-in potential adverse environmental hazards. Much research yet remains to be done so it is not expected to provide significant additions to reserves over the short term.

The Atomic Energy Commission is experimenting in design and testing of nuclear explosives and in techniques for utilizing the effects of multiple nuclear explosives to recover natural gas locked in tight geological formations. Such gas cannot now be economically produced by conventional methods. Most reserves amenable to nuclear stimulation lie in thick, deep reservoirs of very low natural permeability located in the Rocky Mountain area.

Project Gasbuggy, a cooperative effort of the AEC and El Paso Natural Gas Company, involved detonation of a 29 kiloton nuclear device in the Pictured Cliffs formation, a rock strata near Farmington, New Mexico. The device, set off at a depth of 4,000 feet, created a crushed rock cavity of about 0.5 million cubic feet within which most of the radioactivity was contained. From January 10, 1968, when it was set off, to November 1968, 300 million cubic feet of gas was extracted from the cavity.

Projects Gasbuggy and Rulison are essentially pilot experiments involving the detonation of a single nuclear explosive. Both of these projects are clearly demonstrating that recovery of natural gas by nuclear explosion stimulation is technically feasible and economically promising. The next development phase involves techniques for using multiple explosives in a

single wellbore. Gas formations amenable to nuclear explosion stimulation are thicker than can be effectively and feasibly stimulated by a single explosion. The Rio Blanco Project, part of this phase, involved simultaneous detonation of three 30-kiloton nuclear devices more than a mile underground on May 17, 1973. The blast, which registered 5.3 on the Richter scale, is expected to produce 17.5 billion cubic feet of natural gas from sandstone formations at Meeker, Colorado. The gas should fill the cavity created by the blast, from where it can be piped to the surface.

The Atomic Energy Commission has reported on the possible scope of nuclear stimulation and has provided an economic assessment of the technical programs needed to achieve commercially viable application of nuclear stimulation of natural gas wells. The AEC concluded that, based on certain assumptions, "over 10 percent of the Nation's current gas consumption could be met by gas from nuclear stimulation by a development rate of about 50 wells per year." The report indicates, however, that it would take approximately 20 years before gas produced from stimulated reservoirs would be about equal to 10 percent of 1969 consumption. To accomplish this level of production it would be necessary to explode 4,000 nuclear devices of 100 kilotons each in 1,000 wells over 20 years.

Assuming successful development of the technology, the AEC estimates that nuclear stimulation could add some 1 trillion or more cubic feet of natural gas to U.S. production per year beginning in the late 1970's or early 1980's. However, several years of development work are needed before the nuclear stimulation technology will be available for commercial applications.

Environmental effects of nuclear stimulation to increase natural gas production from tight reservoirs are related to radioactivity and seismic disturbance, both of which concern the surface or subsurface, leaving atmospheric contamination or disturbance unlikely. The depth of the gas formations of interest throughout the Rocky Mountain area is such that the probability of releasing any radiation to the atmosphere at detonation time is very low. Most radioactivity produced by the explosives will remain underground trapped in the resolidified rock near the bottom of the chimney or attached to the rock surfaces in the chimney. Project design should take into account mobile waters and assure that chimneys remain isolated from them. The formations of interest for nuclear explosive stimulations are generally at depths of 5,000 to 10,000 feet or deeper, have low permeability, and would not be expected to contain mobile water. Significant vertical communication with shallow water-bearing formations through existing or created faults or fractures could present a serious limitation. Water produced with the gas from nuclear explosive stimulated wells will contain tritium. Control methods to dispose of this contaminant will have to be developed.

The chemical composition of the gas itself in each stimulated well is assumed to be similar to that measured in the first experiments. The initially large carbon dioxide concentration in the chimney would be

reduced by dilution with pipeline gas or carbon dioxide would be removed by standard gas field practices. Gas production from the wells could be delayed until short-lived radionuclides decayed. Technical information from subsequent experiments will aid in defining the time for initiation of production.

The remaining gaseous isotopes, tritium and krypton-85, are calculated to provide less than one millirem per year of exposure to the general population if the gas were used as a part of the total gas supply of a large city. No insurmountable problem is anticipated in meeting future regulations or standards developed for sale of the gas.

The potential environmental impacts resulting from nuclear stimulation of a single well or in a small geographic area have been evaluated in the environmental impact statements prepared for the proposed Phase I Rio Blanco 1/ and Wagon Wheel 2/ projects. Extrapolation of the impact to a full commercial development relates primarily to the frequency and size of explosives and to changes in local environment as the areas of development expand.

AEC's proposed schedule calls for drilling and firing 100 wells per year (for possibly 50 to 60 years). On the average this would involve approximately 370 explosive devices per year--usually three or four explosives in each well. Spread uniformly over the year, simultaneous firing of the multiple explosive loads could result in local area disturbances as often as every 9 days. This would have a substantial impact on wildlife and public residents and visitors. AEC estimates that 4 detonation days per year should suffice for the 30 to 40 wells to be completed for each field area. The size of the explosive required to stimulate the very thick geologic section and the actual seismic effect of such devices are still being evaluated.

In extrapolating the projected or observed impact of test projects, consideration must be given to the total environment of the basin. The site for the Rio Blanco experiment, for example, is relatively isolated. There are thought to be no surface or subsurface structures or operations in the zone of substantial damage. The fact that this will not invariably be true is an important environmental consideration when planning commercial development.

By its nature, nuclear stimulation has a dramatically destructive effect on the natural-gas host rock. The fracture zone should extend 300 to 400

1/ Environmental Statement--Rio Blanco Gas Stimulations Project, U.S. Atomic Energy Commission, Washington, D.C., Dept. Wash., 1519 (April 1972).

2/ Environmental Statement--Wagon Wheel Gas Stimulation Project, U.S. Atomic Energy Commission, Washington, D.C., Dept. Wash., 1324, (April 1972).

feet from the center of the explosion. Also, the compression wave moving out from the explosion can cause spall near a free surface (ground level) or other faulting or fracturing in areas where there are large directional stress concentrations. This leads to concern if other valuable mineral resources exist in the area.

The development of nuclear stimulation of natural gas reservoirs may be accompanied by some possible damage to existing structures due to ground motion. Damages would have to be repaired or compensation rendered to owners. Ground motion is predictable and utmost care would be used to minimize this effect.

It has been suggested that residual stress from a number of detonations might accumulate and present an earthquake stimulation hazard not present in a single detonation. The best evidence available on this point is from experience with the Nevada Test Site, where data from seismic wave generation and from stimulated fault motion indicate that the cumulative effect of many explosions is to reduce ambient stress levels rather than to increase them. A recent series of high-precision geodolite measurements indicate also that the residual strain field around a single explosion site tends to relax with time. In any case, observations of the seismic effects of a series of detonations would permit continuing appraisal of this issue.

(3) Increase Foreign Imports of Pipeline Gas and Liquefied Natural Gas

If projected natural gas demand is to be met, domestic production of natural gas will have to be supplemented in order to fulfill demand. These supplements will come in the form of synthetic gas from coal and/or liquid hydrocarbons or as imports. Natural gas imports could come into the United States via pipeline from Canada or Mexico or as tanker-borne liquefied natural gas (LNG) from other countries.

(a) Pipeline natural gas imports

Pipeline imports of natural gas into the United States have come from the two bordering countries of Canada and Mexico. In 1971, 0.9 trillion cubic feet were imported via pipeline from Canada, while 0.025 trillion cubic feet came from Mexico. There is little prospect for increased imports from Mexico. A relatively small proven natural gas supply base and a policy of "self-sufficiency in energy" indicate that potential new gas will probably not be available for export. Present contracts expire in 1982; thus, if no new supplies of gas are released for export, significant natural gas imports from Mexico could cease at that time. 1/ Future increases in pipeline imports of natural gas will, therefore, have to come from Canada.

1/ Federal Power Commission, Bureau of Natural Gas, National Gas Supply and Demand 1971-1990 Report No. 2, Feb. 1972, p. 57.

Based on actions by the Canadian National Energy Board (NEB), it appears that future increases in natural gas exports from Canada may be limited. In November 1971, the NEB dismissed three applications for licenses to export nearly 2.7 trillion cubic feet of gas to the U.S. The NEB rejected the applications because "... the Board decided that there was no surplus of gas remaining after due allowance had been made for the reasonably foreseeable requirements for use in Canada..." (FPC, p. 51).

The NEB's determination that there was no surplus of gas was based on the method used for calculating the required supply. The Board makes determinations of both current and future natural gas supply when considering export applications. Under NEB requirement, the current gas supply should be adequate to meet authorized deliveries under existing export licenses as well as current Canadian domestic demand for almost 30 years. On this basis, in 1971, there was a supply deficiency of 1.1 trillion cubic feet. The future supply must be adequate, based on a given level of annual reserve additions, to protect existing export licenses and to maintain a reserve to production ratio of approximately 30 for Canada's projected domestic requirements for 20 years into the future. If projected gas supply exceeds projected supply requirements, an exportable surplus results. FPC calculations based on the historical finding rate of 3.5 trillion cubic feet per year, show that supply could fall 23.4 trillion cubic feet short of these requirements (FPC, p. 51).

Recent discoveries in the Arctic Islands, Mackenzie Valley, and Atlantic offshore regions will eventually, however, result in larger reserve additions. The NEB will not consider these new discoveries in its reserve calculations until they have been developed sufficiently to be within economic reach. If the discoveries continue and are developed, major surpluses may become available for export by the end of this decade.

Table IV-22 shows various projections of pipeline imports from Canada. The environmental impacts of pipelines carrying gas from Canada and Mexico would be essentially the same as for pipelines for movement of domestic resources.

Natural gas from the Alaska North Slope probably will be transported to the U.S. via a trans-Canadian pipeline as costs would be considerably less than liquefaction and vessel transport. However, until the North Slope pipeline issue is resolved and production of oil begins, gas plans cannot be finalized.

The Prudhoe field has large reserves of natural gas dissolved in or associated with its crude oil reserves. Recoverable gas reserves in the field were estimated to be 26 trillion cubic feet as of the end of 1970. An average of 750 cubic feet of dissolved gas per barrel 1/ for the proved

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1/ Suggested by the data given in Bureau of Natural Gas, Federal Power Commission, National Gas Supply and Demand: 1971-1990, pp. 98-99.

Table IV-22

Pipeline Imports from Canada
(trillion cubic feet)

	1975	1980	1985
FPC 1/	1.2	1.6	1.9
Interior 2/	2.0	3.0	4.1
NPC 3/	1.0	1.6	2.7

1/ Federal Power Commission, Natural Gas Supply and Demand, 1971-1990, Staff Report No. 2, February 1972, p. 57.

2/ Department of the Interior, U.S. Energy Through the Year 2000, p. 45. (Includes Mexican imports)

3/ National Petroleum Council, U.S. Energy Outlook, p. 267.

oil reserves of 9.6 billion barrels would indicate reserves of approximately 7 trillion cubic feet of dissolved gas and 19 trillion cubic feet of associated gas. These reserves which, like the crude oil reserves of the Prudhoe Bay field, are subject to extension and revision constituted 8.9 percent of recoverable U.S. natural gas reserves at the end of 1970. They also make the Prudhoe Bay field the 13th largest gas field ever discovered in the world (National Gas Supply and Demand: 1971-1990, p. 74).

The estimated reserves of the Prudhoe Bay field do not exhaust the oil and gas potential of the Arctic Slope province in Alaska. The Prudhoe Bay field is located in the Colville Basin. Geologically, this basin is classified as an intermediate crustal type (i.e., its underlying crust is intermediate to that beneath continents and that beneath oceans), the basin itself being extracontinental (located on the margin of a continent) and sloping downward into a small ocean basin. Extracontinental, downward warping basins are among the richest sources of oil and gas in the world. Examples of such basins include the Arabian platform and Iranian basin (Persian Gulf), the East Texas basin, and the Tampico embayment (Mexico). Over half of the 119 known oil fields with at least 1 billion barrels of recoverable reserves are found in the 10 known basins of this type (Halbouty).

The ultimate potential of the onshore area in the Arctic Slope province is uncertain. The platform along the Arctic Coast gives considerable geologic indications of being very favorable for both oil and gas (Gryc, 1971). Comparison with the history of similar basins indicates a high probability of further discoveries of varying size. Professional estimates of ultimate recovery for the province range from 30 to 50 billion barrels (Cram). Recall, here, that the Prudhoe Bay field alone is likely to supply 20 billion barrels of crude oil. Considerably higher estimates than these have been made, 1/ but the geologic evidence for them is lacking.

Similarly, the natural gas prospects of the North Slope are not limited to the Prudhoe Bay field. Several gas fields were discovered in the 1940's and 1950's on NPR-4, the largest of which was the Gubik field with 300 billion cubic feet of reserves. Geologic investigations of other parts of the North Slope have indicated a favorable potential for future gas discoveries within them as well.

(b) Import of Liquefied Natural Gas (LNG)

Because of the growing shortage of domestic gas supplies, plans now are being made by the gas industry for baseload LNG imports under long-term contracts. LNG imports cannot, however, simply be increased to meet the demands for greater supplies of natural gas. Large-scale shipping of

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1/ Governor Egan of Alaska was quoted in The Oil Daily, July 7, 1971, p. 3, with an estimate of 150 to 300 billion barrels.

LNG is a relatively new industry and the United States does not yet have facilities for receiving baseload shipments. The FPC recently approved two projects which together call for deliveries of the equivalent of more than 1 billion cubic feet/day of LNG. Several other projects have been proposed and are pending approval. Future import levels will, therefore, be dependent on the rate of buildup of the United States' LNG industry.

In 1971, non-Communist natural gas proved reserves were estimated to be 1,033 TCF and production was 138 TCF. The estimate of future discoverable reserves was 6,167 TCF (NPC). It appears, therefore, that sufficient supplies of natural gas will be available for export to the United States. Following is NPC's estimate of maximum LNG imports and a breakdown by source country. The second column shows the calculated backup of reserves necessary to support the estimated level of exports to the U.S. (based on 12.5 billion cubic feet of reserves for each million cubic feet per day of export), and the third column shows proved reserves as of January, 1971.

1985 LNG IMPORT PROJECT SUPPLY

Country	LNG Projects (MMCF/Day)	Calculated Reserve Backup (TCF)	1/3/71 Reserve Estimate
Algeria	4,350	54.4	106.5
Nigeria	3,500	43.8	40.0
Venezuela	1,000	12.5	25.4
Trinidad	300	3.8	5.0
Ecuador	500	6.3	6.0
Pacific	1,000	12.5	42.9

Even without further discoveries, these countries appear to have sufficient reserves to support exports to the United States. LNG receiving points will be primarily located on the east coast with other projects on the Pacific and Gulf coasts.

The primary advantage of liquefying natural gas is the more than 600 to one volume reduction which results. LNG was first used by gas utility companies for peak shaving and satellite facilities and for remote and emergency deliveries. With the development of technology for marine transportation of LNG, large new sources of natural gas have become available to the United States. Several processes exist for liquefying natural gas. Two primary methods are: (1) the transfer of heat through separate refrigerants to air or water, and (2) permit the gas to do work through the use of an expander.

Insulated storage is required for the LNG both after it has been produced and before it is regasified. The most frequently used storage tanks for baseload operations have been aboveground, double-wall metal tanks. The space between the walls is filled with insulation, a partial vacuum, or both. Prestressed concrete tanks have been used for other cryogenic fluid storage and may be applied to LNG.

LNG is regasified by circulation through tubes. The heat for the process is obtained from the surrounding air or water or is produced by the combustion of a fuel such as some of the natural gas itself. After LNG has been regasified, it can be introduced into conventional natural gas pipeline systems.

LNG imports will have an impact on United States balance of payments. At this point in the development of the program it is difficult to determine what this impact will be. Capital from the United States will undoubtedly be involved in the construction of liquefaction plants. The Export-Import Bank, for example, is providing some of the funds necessary for the construction of an Algerian plant. It has not been established, however, just how much U.S. capital will move to exporting countries or how much money will return through the purchase of U.S. equipment. The use of foreign or domestic tankers will also be a factor in the balance of payments. The cost of the gas itself will, however, probably have the greatest influence on balance of payments. One estimate of the f.o.b. price of gas is 38¢ to 53¢/Mcf. 1/ Importing 1 TCF could, therefore, result in an outflow of $380 to $530 million. It should be noted that the various potential source countries represent a wide range of propensities to import from the U.S. (see table IV-19 in previous section)

The price to the consumer of imported LNG is also difficult to project. The FPC, in approving the El Paso Natural Gas Co. application to import LNG, limited initial prices to 77¢ per million Btu's delivered to Cove Point, Maryland, and 83¢ at Savannah, Georgia. The company has indicated that the allowed prices may be insufficient. The current prices for natural gas in the United States, under the area rate method, range from 22.5 to 34.0¢/Mcf. Under the FPC's new optional pricing system, the price of new gas is higher. The first applications under this policy have proposed to sell gas for 45¢/Mcf.

The environmental impacts in the United States of LNG imports would be those of (1) tankers, (2) terminal, transfer, and regasification facilities, and (3) transportation and combusion of the gas.

Tankers. Any seagoing vessel may be involved in collison or other mishap. However, escape of LNG to the environment would not necessarily result in significant impact. Since LNG remains liquid only at -259° F at atmospheric pressure, any spilled LNG would immediately begin to vaporize and, although it would pollute the air, would have little impact on land or water resources. Studies on the possibilities of explosions resulting from LNG spills are inconclusive. Tests indicate that under certain conditions small-scale explosions result when the LNG is poured onto water. These results cannot be extrapolated to predict the result of a large-scale spill on open water (USDI, Bureau of Mines, 1970).

1/ Amanullah R. Khan and William W. Bodle, "Supplementing United States Gas Supplies With Imported LNG," Journal of Petroleum Technology, May 1972.

Another study concluded that there was little danger of normal LNG exploding when spilled on water and that a vapor explosion could result only after the methane content of the LNG had reached 40 percent. Since the normal methane content of LNG is 80 to 90 percent or more and the boil-off rate is 0.2 percent per day, a reduction to 40 percent is not likely with present day shipping practices (Engen, 1972). Worldwide experience to date in the handling and shipping of LNG has resulted in no serious explosion or fire. Since commercial delivery of LNG by tanker began in 1961, there have not been any accidents at sea. However, although LNG spills have been reported, they have not been serious.

Transfer and Storage. Each regasification plant will require facilities to permit the transfer of LNG from tankers to storage areas. At Cove Point, Maryland, this will be accomplished by the construction of a mile-long pipeline into the Chesapeake Bay. At the proposed Savannah plant a channel and a turning basin would be dredged in the Savannah River to allow the tankers to come close to the plant. Both of these methods will require initial dredging, and possibly continued dredging, causing increased turbidity of the water and disruption of marine animals, especially in the case of bottom dwelling organisms. In most cases this disruption would be temporary, but care would have to be taken to avoid as much as possible commercial fishing areas. The potential for fire or explosion is always present during the transportation, transfer, or storage of LNG. Since spilled LNG would not vaporize instantaneously, the release of the equivalent of several million cubic feet of gas, for example, might cause a fire which could continue until all the LNG had vaporized. An early LNG plant was destroyed by a disastrous fire in 1944 due to the failure of a storage tank, with a loss of more than 100 lives. Since then, many improvements have been made in the technology of storage and handling of the LNG, and increased attention has been given to proper safety precautions. The recent explosion of a Staten Island storage tank, killing more than 40 men, shows that there is still, however, an element of danger involved in the storing and handling of LNG.

Regasification. The construction of regasification plants will have an impact on land resources. The extent and duration of the impact will depend on the size and location of the plant. For example, the plant proposed for Cove Point would produce initially 650 million cubic feet per day and require a 1,022-acre tract of land; another plant proposed for Savannah, Georgia, would produce initially 335 million cubic feet per day and require 860 acres, or 1.5 to 2.5 acres per million cubic feet capacity. During construction there will be some disruption of the land surrounding the plant and some damage to animal habitats. This damage will be permanent only in the area occupied by the plant and supporting facilities.

Since natural gas or water will be used to regasify the LNG, very few pollutants will be released to air or water. Plants using water to regasify LNG will release the water at a lowered temperature. In the

case of the Savannah plant, water temperature will be lowered 5° F before being returned to the river.

A regasification plant could have an impact on the scenic and recreational resources of an area. The choice of the plant site is an important factor in minimizing the impact on scenic qualities and recreational activities. The increase in ship traffic could have an effect on water-oriented recreational activities.

Impact of Combustion and Transportation. Since natural gas is a relatively clean burning fossil fuel, the impact on air quality would not, therefore be significant. LNG imports will require the construction of new pipelines

(4) Synthetic Gas from Coal and Oil

The production of synthetic gas from coal was discussed under the coal alternative. Coal gasification technology has not yet been fully developed and most processes have not advanced beyond the pilot plant stage.

The CO_2 acceptor process and HYGAS process are currently at pilot plant stage with partial operational tests on certain units. The Bigas process is at pilot plant construction stage. The above three, along with the Lurgi process, are the most advanced in development among all coal gasification methods. Table IV-23 shows the status of various projects.

The Lurgi process, without the methanation step, is employed in several plants in West Germany and other parts of West Europe to produce low-Btu value gas (400-450 Btu/cf). Catalytic methanation, required to achieve pipeline quality of 1,000 Btu/cf, has not yet been commercially demonstrated. The first commercial scale test of production of pipeline coal gas will be undertaken by Conoco Methanation Company, which will add methanation facilities to the Scottish Gas Board's Westfield coal gasification plant. This plant uses the Lurgi process. The first commercial plant to produce pipeline coal gas, also using the Lurgi process, will be built by El Paso Natural Gas Company near Four Corners, New Mexico. The 250 million cubic feet per day plant, costing about $250 million, is expected to be in operation by 1976.

In August 1971, the Department of the Interior and the American Gas Association signed an agreement for an accelerated program for coal gasification which will cost about $120 million over 4 years. Three pilot plants will be in operation under the program. In each of the plants a unique gasification method will be tried in conjunction with different systems of gas cleanup and methanation so that a final process, combining the best features of the individual processes, can be chosen.

Part of the funds will go to the Applied Technology Corp. for development of the ATGAS process which uses a unique molten-iron gasification technique to gasify all types of coal (regardless of sulfur content) with

Table IV-23

Tabulation of Coal Gasification Projects*

Company	Site	Process	Status
IGT	Chicago	HYGAS	Pilot plant partially operating: preliminary demonstration plant design completed.
Consolidation Coal Co.	Rapid City, S.D.	CO_2 Acceptor	Pilot plant started up.
Bituminous Coal Research, Inc.	Homer City, Pa.	BI-GAS	Pilot plant construction underway.
U. S. Bureau of Mines	—	Synthane	Pilot plant being designed.
FMC Corp.	—	COGAS	Partners being sought to design and build a $250-$300 million commercial plant producing 250 million CF/day gas and 24,000 bbl/day syncrude.
El Paso Natural Gas Co.	Four Corners, N. M.	Lurgi	Design contract awarded to Stearns-Roger Corp.: plant scheduled for completion in 1976.
Texas Eastern Transmission Corp., Pacific Lighting Corp., and Utah International Inc.	Four Corners, N. M.	Lurgi	Feasibility study awarded to Fluor Corp.: plant operation planned for early 1976.
Texas Eastern and Eastern Gas & Fuel Associates	Four Corners, N. M.	Lurgi	Coal mining and prospecting rights bought.
Panhandle Eastern Pipe Line Co. and Peabody Coal Co.	Illinois	Lurgi	Feasibility study awarded to M. W. Kellogg Co. and American Lurgi Corp.
Conoco Methanation Co. and Scottish Gas Board	Westfield, Scotland	Lurgi Gas Methanation	Conoco will design and build facilities for 1 yr of testing, beginning in mid-1973 of the methanation system. Sponsors being sought.
South African Coal, Oil and Gas Corp. and Lurgi Gesellschaft	Sasolburg, South Africa	Lurgi Gas Methanation	Experimental program to demonstrate commercial feasibility of methanation.
M. W. Kellogg Co.	—	Kellogg Molten Salt	Support sought for construction of large-scale pilot plant.
Garrett Research and Development Co. (sponsored by Colorado Interstate Gas)	—	—	Process to produce gas by rapid devolatilization of coal tested in bench-scale pilot plant.
Gulf General Atomic Co. and Stone & Webster, Inc.	—	—	Feasibility studies underway.
Commonwealth Edison Co.	—	Lurgi	Production of low-Btu gas studied for use in power plant boilers: $23.5 million demonstration plant proposed.
Coteau Properties and Michigan-Wisconsin Pipe Line Co.	—	—	15-yr option on lignite reserves taken.
Colorado Interstate Gas Co. and Westmoreland Resources	—	—	10-yr option on coal reserves taken: feasibility of plant to be studied.
Columbia Gas System, Inc.	—	—	Core drilling on West Virginia coal reserves proved 293 million tons recoverable.
A. D. Singh Co.	Terre Haute, Ind.	Fluidized-Bed Carbonization	Site being cleared for construction of 115 million CF/day plant.
The Koppers Co.	Pittsburgh, Pa.	Koppers-Totzek	Koppers licensed to market process originally designed to produce a gas for ammonia production.

* Compiled by Institute of Gas Technology.

Source: Robert Sisselman, "Coal Gasification a Partial Solution to the Energy Crisis," Mining Engineering, vol. 24, no. 10 (Oct. 1972), p. 74.

steam and oxygen at low pressure. The process produces a gas suitable for conversion to SNG. Extreme flexibility with regard to physical properties and sulfur content of coal enable economical use of coals for which there are few other markets. Construction and operation of a pilot plant is planned. Also under the program, Columbus Laboratories of the Battelle Memorial Institute is working on development of a coal-gasification fluidized-bed coal burner to provide the heat for steam gasification of coal. A pilot plant will be operated to obtain performance data for assessment of the commercial potential of the process.

An important part of the program is the development of the BI-GAS process to produce pipeline quality gas. The core of this process is the two-stage gasifier which uses pulverized coal in entrained flow. A pilot plant in Homer City, Pennsylvania, is presently under construction and scheduled for start-up in 1974. Advantages of this process are (1) a high yield of methane obtained directly from coal with minimal subsequent processing of the product gas, (2) no tars and oil are formed in the gasification process, (3) all the feed fuel is consumed in the process, and (4) the two-stage gasifier is relatively simple in design and amenable to scale-up to any size.

The economics of coal gasification will be greatly influenced by finalized process configurations. Present emphasis is on processes whose major end product is pipeline quality gas with minor credits for by-products such as sulfur and phenol. Further advances may result in an optimized process which produces not only pipeline gas but also liquid and solid hydrocarbon fuels and electric power.

Natural gas can also be synthesized from petroleum. Such gas has been produced commercially in Europe and some 40 plants are in the planning stage for the United States. Feedstocks used are naphtha, other lighter hydrocarbons, or methanol. While the gasification of oil does not add to overall energy supplies, it does provide an additional flexibility in energy form. Processes under consideration include:

1. Thermal cracking in steam
2. Thermal cracking in a hydrogen-rich atmosphere
3. Catalytic cracking in steam
4. Partial oxidation

Currently much attention is being given to catalytic rich processes developed by the British Gas Council. Called the CRG (Catalytic Rich Gas) process, it can gasify a wide variety of hydrocarbon feedstocks, though attention now is concentrated on naphtha feedstocks. A CRG plant involves two basic operations:

1. Feed preparation, including fractionation and desulphurization
2. The CRG process, per se, including gasification, and methanation to a gas with a heating value of 980 Btu per cubic foot

Desulfurization of the feedstock is accomplished by mixing the feed with hydrogen-rich gas, vaporization, and treatment with nickel-molybdate and zinc oxide catalyst. If sulfur is to be recovered, the sulfur-rich fraction is hydrodesulfurized.

Department of the Interior forecasts for production of synthetic gas are:

	Total Gas Produced		Energy Inputs	
			Coal	Petroleum
Year	bil. cu. ft.	tril. Btu	mil. tons	mil. bbl.
1980	700	700	19	84
1985	2,000	2,000	86	128
2000	5,500	5,500	308	105

Factors that will influence the rate of growth of a coal gasification industry are the availability of coal and petroleum feedstocks, the development of needed mining capacity (including availability of manpower for mining), availability of capital, and availability of refining capacity to provide light hydrocarbon for feedstocks.

The National Petroleum Council has estimated SNG production from petroleum feedstocks at 0.6 trillion cf in 1975 and 1.3 tcf in 1980 and remaining at that level to 1985. These figures reflect the assumptions that one third of announced plants will be operating by 1975 and one half of plants scheduled to be in production in 1980 and 1985 will be completed on schedule. These assumptions show the retarding effects of Government regulations, import restrictions, and siting and administrative delays.

(1) Environmental Impact

Like natural gas, synthetic (also called substitute) natural gas and oil from coal are clean-burning fuels because the sulfur has been reduced to very low values, and no particulate matter is emitted at the point of combustion. Coal gasification and liquefaction share the same environmental problems as use of coal for boiler fuel. These begin with coal mining. One of the most pressing problems is air pollution from sulfur content of coals. These problems are discussed fully in the section on coal.

Impact on Air Quality. Plant operation, consisting of handling and transporting the coal to the process and converting the coal to gas and/or oil, will involve very large quantities of devolatilized coal, called char, which will be burned in boilers to generate process steam and power or gasified to make process hydrogen. Major emissions that must be controlled are sulfur and nitrogen oxides and bottom ash and fly-ash from the plants generating process steam and power. Fly-ash emission boiler stacks can be controlled, and furnace-bottom ash and slag are handled

routinely without environmental problems. However, it may become desirable to locate large coal conversion plants near large strip mines where ash and slag from the process would be returned to the open cuts and the ground restored in accordance with environmental considerations. The technology for controlling sulfur and nitrogen oxides from such plants is under development.

To illustrate the order of magnitude of the major emissions that would have to be handled from a commercial coal-to-pipeline gas plant, the FPC's National Gas Survey gave the following estimates, based on a plant producing 250 million standard cubic feet per day of pipeline gas 1/ from coal with 3.7 percent sulfur:

	Long tons per day
Sulfur (mainly as hydrogen sulphide)	300-450
Ammonia	100-150
Phenols	10- 70
Benzene	50-300
Oil and tars	trace-400
Ash (based on coal with 10% ash)	1,500

Source: FPC, National Gas Survey, 1973 (Supply-Technical Advisory Task Force, Synthetic Gas-Coal, Final Report, Ch. X, Environmental Considerations, p. X-2).

The environmental impacts of SNG plants using naphtha feedstock are expected to be less than those of comparable coal-based synthesis plants because they would be free of ash and char, and sulfur oxides and particulates discharge problems.

Impact on Water Quality. Plant operation involves very large quantities of water for cooling and scrubbing gases. The discharge of contaminants such as phenols, cresols, benzene, oil and tars must be controlled, Process waste solids such as spent dolomite may present problems of surface water contamination.

Impact on Land Quality. Waste solids such as char, granulated extract, and powdered sulfur must be disposed of at approved land fill areas.

1/ This size SNG plant produces the equivalent of 40,000 bbls. per day of crude petroleum.

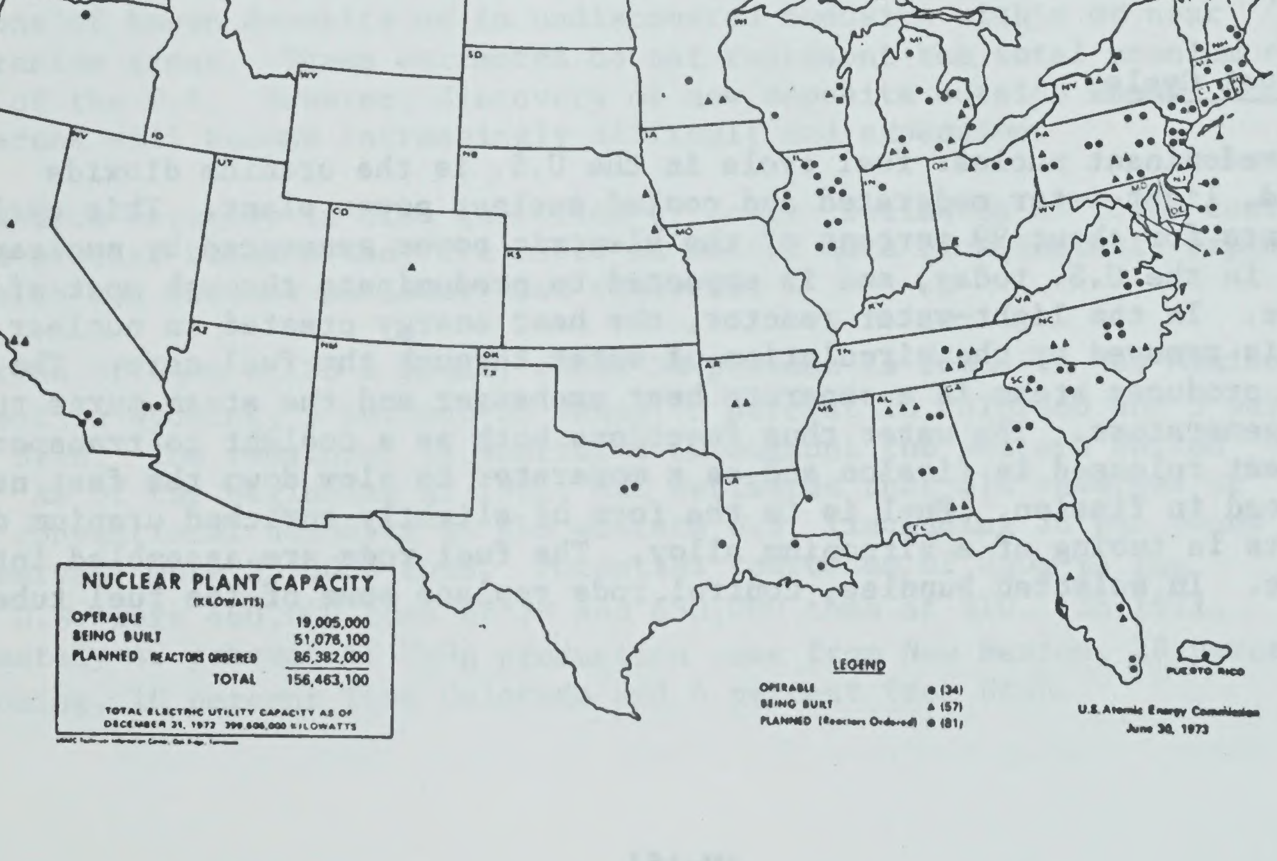
e. Nuclear Energy

Additional nuclear steam-electric powerplants could be substituted for geothermal electric generation. Three types of nuclear powerplants are theoretically possible: burner (light-water or gas-cooled), breeder, and fusion. Only the first has reached commercial production.

At the present time, neither breeder nor fusion reactors are practical alternatives and considerable research will be required to demonstrate their technical and economic feasibility. Even if the breeder reactor is developed, it is expected that most nuclear capacity through the year 2000 would be additional nuclear powerplants using burner reactors consuming naturally occurring isotopes of uranium.

The use of nuclear power as a commercial energy source is expected to increase considerably in the next 15 years. Installed U.S. capacity currently is approximately 14,000 MW. This is projected to increase to 46,000-61,000 MW by 1975, 120,000-139,000 MW by 1980, and 198,000-286,000 MW by 1985. The variance in these estimates is, in part, due to delays in the licensing of the construction and operation of currently planned or completed units because of concern over their environmental effects (from waste heat disposal, normal or accidental radioactive emissions, etc.).

NUCLEAR POWER REACTORS IN THE UNITED STATES



Nearly all of the currently operating and planned nuclear plants utilize light water, either boiling water or pressurized water reactors. In the boiling water reactors, the heat energy created in nuclear fission is removed by the circulation of water through the fuel core which generates steam to turn the turbine generators that produce electricity. In pressurized water reactors (comprising approximately two-thirds of existing or ordered capacity), the steam is generated indirectly, utilizing a secondary cooling system. Four high-temperature, gas-cooled reactors are also completed or on order in the United States. These utilize helium circulation through the fuel core (primary system) to boil water (secondary system), creating steam to turn the turbine generators. On the basis of presently proven feasibility, a single nuclear powerplant could substitute for geothermal generation at a level of 1,000 to 2,000 MW capacity. For the higher estimated potential of 7,000-20,000 MW (National Petroleum Council, 1972), four to 10 plants would be required.

The major environmental problems which could occur as a result of additional nuclear power development include the disposal of overburden, waste rock, and tailings from the mining of uranium ore; changes in land use; disposal of the waste heat; a risk of a disastrous accident; and ensuring the safe transport and storage of highly radioactive waste materials.

Since specific impacts depend upon where the particular activities constituting the nuclear fuel cycle would be located, a description of specific impacts applicable to all locations is not possible. Throughout this statement, the impacts described are considered to be a quantitive addition to similar impacts of existing or planned nuclear facilities.

(1) Fuel Cycle

The predominant nuclear fuel cycle in the U.S. is the uranium dioxide fueled, light-water moderated and cooled nuclear power plant. This cycle accounts for about 99 percent of the electric power generated by nuclear fuels in the U.S. today, and is expected to predominate through most of this decade. In the light-water reactor, the heat energy created in nuclear fission is removed by the circulation of water through the fuel core. The heated water produces steam in a separate heat exchanger and the steam turns turbine generators. The water thus functions both as a coolant to transport the heat released in fission and as a moderator to slow down the fast neutrons produced in fission. Fuel is in the form of slightly enriched uranium dioxide pellets in tubing of a zirconium alloy. The fuel rods are assembled into a bundle. In selected bundles, control rods replace some of the fuel tubes.

The specific components of the light-water supporting fuel cycle include the following:

1. Mining uranium ore.

2. Milling and refining the ore to produce uranium concentrates.

3. Production of uranium hexafluoride from uranium concentrates to provide feed for isotopic enrichment.

4. Isotopic enrichment of uranium hexafluoride to attain reactor enrichment requirements using the gaseous diffusion process.

5. Fabrication of nuclear reactor fuel including converting uranium hexafluoride to uranium dioxide, pelletizing, encapsulating in rods and assembling fuel elements.

6. Reprocessing irradiated fuel and converting uranium to uranium hexafluoride for recycle through the gaseous diffusion plant for reenrichment.

7. Radioactive waste management of high level and other wastes, including long-term storage of wastes.

8. Transportation of materials to and from each of the above operations.

(2) Resource Base

AEC develops estimates of two types of uranium resources. "Reserves" refers to known deposits that can be economically produced at a given cost. "Potential resources" refers to additional uranium that may exist in unexplored extensions of known deposits or in undiscovered deposits within or near known uranium areas. These estimates do not represent the total uranium resources of the U.S. However, discovery of new deposits outside known mining areas will become increasingly difficult and expensive.

Each resource category is also qualified by cost. Estimates at lower costs are more precise because they are based on better data from industry exploration, which has focused on lower cost reserves.

Of reserves of U_3O_8 at $8 a pound, about 50 percent is found in New Mexico, 35 percent in Wyoming, 5 percent in Texas, 3 percent in Colorado and 3 percent in Utah. The remainder is scattered throughout the western United States. As of the beginning of 1972, AEC estimates that $10 reserves of U_3O_8 in conventional deposits in the western U.S. (including $8 per pound U_3O_8 reserves) were 333,000 tons. Potential resources of U_3O_8 in the western U.S. were 460,000 tons at $8 and 650,000 tons at $10. In 1971, approximately 42 percent of U_3O_8 production came from New Mexico, 28 percent from Wyoming, 10 percent from Colorado and 6 percent from Utah.

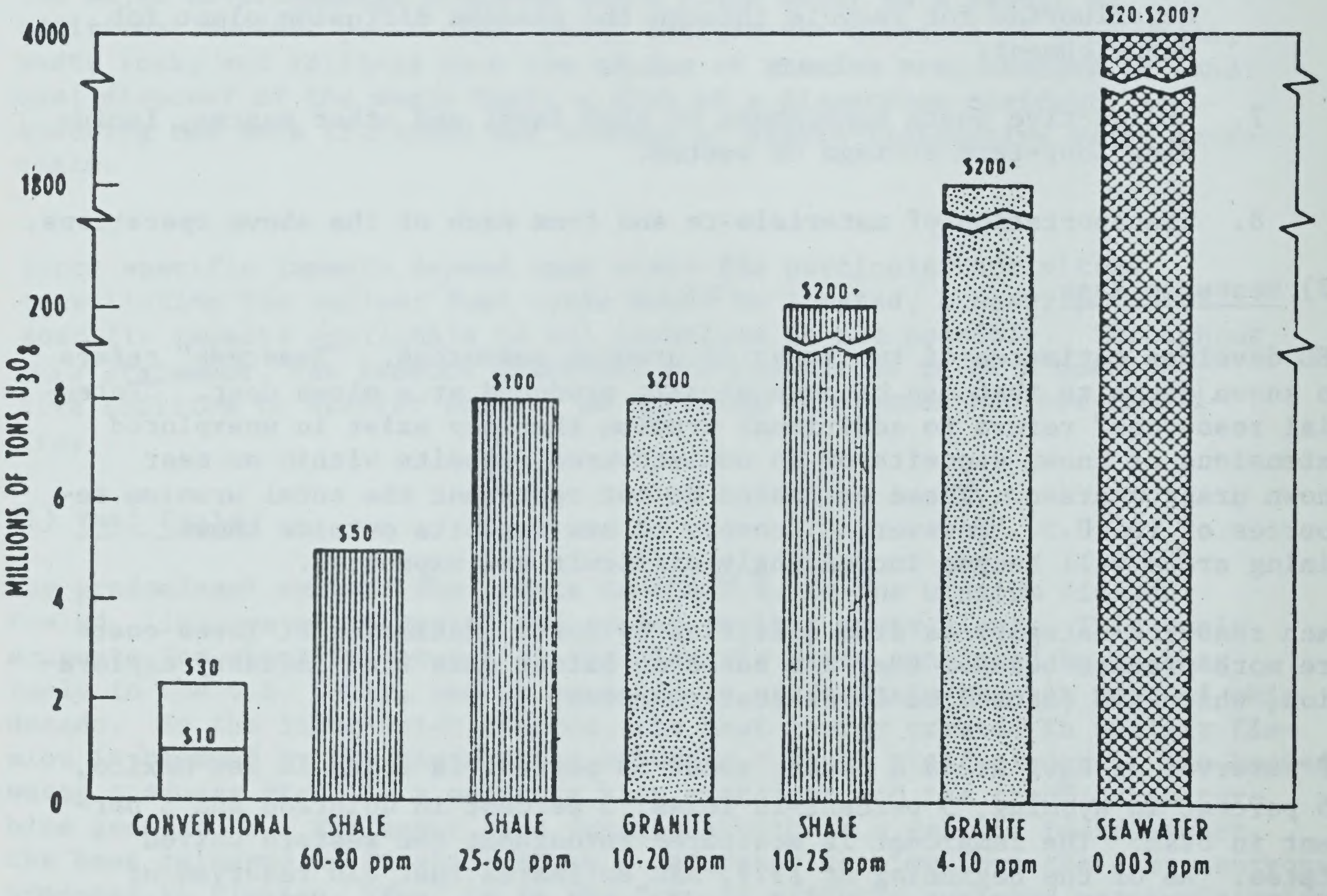
(3) Economic Considerations

Adequacy of uranium reserves depends on the resource base being considered. An extreme gap between uranium requirements and resources is shown if resources are confined to the \$8 per pound U_3O_8 reserves. This gap narrows progressively with the inclusion of \$8 per pound potential resources, \$10 per pound reserves, \$10 per pound potential resources, and so on.

Figure IV-2 below shows U.S. uranium resources at different prices. Table IV-24 shows uranium production, reserves and potential. 1/ These figures may be compared to AEC estimated requirements from 1972 through 2000 of 2,400,000 tons of U_3O_8, or more than 10 times total past production in the U.S. to date.

FIGURE IV-2

U.S. URANIUM RESOURCES AT \$10 TO \$200 PER LB. U_3O_8



1/ Remarks by Robert D. Nininger, Asst, Director of Raw Materials, Div. of Production and materials management, AEC, before the Atomic Industrial Forum, Uranium Seminar, Oak Brook, Illinois, March 27, 1973.

TABLE IV -24

PRODUCTION, RESERVES AND POTENTIAL COMPARED TO REQUIREMENTS

Tons U_3O_8

	1948-1971 Production	Cut-off Cost	Reserves	Potential	Total
Ambrosia Lake, New Mexico (the largest U.S. uranium district)	64,000	\$ 8	58,000	29,000	151,000
		\$15	87,000	59,000	210,000
Other, New Mexico	31,000	\$18	79,000	196,000	306,000
		\$15	113,000	393,000	537,000
Wyoming	43,000	\$ 8	95,000	100,000	238,000
		\$15	164,000	275,000	482,000
Other, U.S.	97,000	\$ 8	41,000	135,000	273,000
		\$15	156,000	273,000	526,000
Total U.S.A.	235,000	\$ 8	273,000	460,000	968,000
		\$15	520,000	1,000,000	1,755,000

Although uranium at costs up to \$15 per pound may be economically competitive in water reactors in the future, the effort to develop the capability to produce such low-grade ore will not begin until there are indications of a market at that price. The uranium content of \$15 resources ranges from 0.10-0.12% U_3O_8 compared to 0.20-0.22 for \$8 resources. Therefore, almost twice as much ore must be mined and processed to produce an equivalent amount of uranium. Industry capacity would have to be doubled to maintain existing U_3O_8 production levels.

(4) Uranium Mining and Milling

The construction and operation of additional nuclear generating plants would require additional mining and milling of uranium ore to supply the fuel for these new plants. An incremental operating capacity of 2,000 MW would require 1,070 tons of U_3O_8 for the first core fuels and 350 tons of U_3O_8 for annual reloads without plutonium recycling and 240 tons of U_3O_8 with plutonium recycling. At an average ore grade of 0.20 percent U_3O_8, a total ore output of 567,000 tons would be required to supply the uranium for the first core fuels, and an annual output of 120,000 to 176,000 tons would be required for reloads. If the estimated 20,000 MW geothermal capacity is realized, the fuel requirement would be proportionally higher. Since the average ore grade can be expected to decline during the life of the plants, the estimated annual ore tonnage for reloads would increase, particularly after 1990. As the estimated geothermal potential of 7,000-20,000 MW is small compared to projected nuclear development, whether or not the Federal geothermal program is implemented, would have little effect on uranium production.

Uranium mining and milling in the United States is concentrated in New Mexico, Wyoming, the Colorado Plateau, and south Texas. As most of the known and potential reserves are concentrated in New Mexico, Wyoming, and the Colorado Plateau, the incremental increase in mining and milling activity would be expected to occur there. In 1970, 53 percent of production came from underground mines, with the remainder coming from surface mines. However, the ratio of production between underground and open-pit mines is expected to change considerably over the next several decades.

In underground mining, excessive exposure to radon daughter products is associated with a high incidence of lung cancer. The recommended annual exposure levels have been greatly reduced in the past decade. If these are maintained and enforced, the incidence of lung cancer among underground uranium miners is expected to be reduced to a level not significantly higher than that of the population as a whole.

Uranium mining is largely concentrated in relatively isolated areas distant from large population centers and urban areas. Nonetheless, it does have an adverse aesthetic impact in the areas in which it

occurs, from the removal of the vegetative cover, overburden and the creation of waste rock. It also may require considerable acreage, reducing (depending upon location) the suitability of that area for other land uses such as grazing, wildlife, and some types of outdoor recreation. Open-pit mines especially require large acreages and expanded production from these mines would necessitate larger areas for placement of stripped overburden and other waste rock. This is a particularly acute problem for uranium as opposed to other types of open-pit mining, given the comparatively high amount of overburden removed for the quantity of uranium ore produced. For underground mining, the extraction of deeper ores will tend to require continually larger waste rock dump areas. Planning for sequential land uses, followed by the reclamation of mined land and the backfilling of mined out stopes with waste rock could, however, substantially reduce these land-use problems.

Because of the low concentration of U_3O_8 in uranium ore, milling the ore produces a considerable amount of tailings. The uranium milling operation required for 2,000 MW of capacity over a 25-year operating life is expected to generate around 4 to 5 million tons of tailings. These tailings contain radioactive daughters (such as radium). Left exposed on the surface, these tailings are subject to erosion and leaching, with the radioactive daughters entering surface and ground water systems. In areas downstream from milling operations, concentrations of these elements substantially above recommended limits have been found in river water, river sediments, flora, and fauna. The specific adverse effects of radioactivity on the overall health of biota are not fully known. Current evidence does, however, indicate increasing concentrations upward in the food chain. Adequate methods exist to prevent erosion and leaching and to retain harmful mill effluents at present levels of production. However, expanded production may require the design of improved systems to handle the growing volumes of waste if the adverse effects noted above are to be avoided.

Because of their radioactivity, mill tailings pose long-term risks to human health if used as fill material. They are also a hostile environment for nearly all biota. Above-ground storage designed to minimize erosion requires that the tailings be covered with gravel or dirt upon which a vegetative cover can be established. Above-ground storage does, however, require considerable land area, again displacing other potential uses. Accordingly, in the future an increasing amount of tailings may be utilized to backfill mined out areas.

(5) Powerplant Construction and Operation

Assuming present technical and economic constraints, the construction of additional nuclear capacity as an alternative to geothermal capacity of 2,000 MW would require a single site. Under current siting criteria,

this would be located at some distance from population centers and would require about 500 acres of land from which some other human uses would be excluded, although many utilities are planning for multiple use of such lands. The higher estimated level of 7,000-20,000 MW would require proportionally more land.

Since both nuclear and geothermal plants are generally located at considerable distances from population centers, land required for transmission rights-of-way would be comparable. Depending upon the capacity of the powerline, an estimated 10 to 15 acres of land per mile of line would be required. This land would be excluded from development although it would still be available for less intensive uses. These transmission lines would have an adverse aesthetic impact, disrupting some scenic vistas.

Construction of a nuclear plant(s) would present some short-run environmental problems. Unless special measures are taken, erosion of excavated materials with subsequent siltation of streams can be expected.

Operation of a nuclear plant will generate considerable amounts of waste heat, however, these plants have a comparatively higher thermal efficiency (around 33 percent compared to 15 to 20 percent for geothermal steam generating plants). Given this difference in efficiency, a geothermal plant, on the average, will require considerably more cooling water and release more waste heat per comparable generating capacity than a light water reactor. The effects of this waste heat will depend upon the cooling method used and the location of the plant. Total water use for mining, milling, and refining uranium ore and preparation of fuel elements plus nuclear powerplant needs is, however, greater than that required for comparable geothermal power outputs.

The use of wet cooling towers, which are generally employed at nuclear plants, to remove the heat by evaporation into the atmosphere would not pose problems of thermal pollution of water bodies. However, water vapor from the cooling operations can have substantial effects on local haze, fog, cloud, and ice formation. Chemicals released in the cooled water or evaporation plume could have adverse effects on downstream and downwind biota.

The use of cooling ponds would produce less evaporation than wet cooling towers, but haze, fog, cloud, and ice formation would still occur during periods of low temperatures. The ponds would, however, require additional land acreage (an estimated 1,000-2,000 acres per 1,000 MW unit). These ponds may have recreational uses but they would also displace other land uses.

Nuclear powerplants, unlike geothermal plants, do not emit certain noxious noncondensible gases which generally accompany geothermal steam. Hence, nuclear powerplants do not create the air pollution problems stemming from, or requiring control measures for, such emissions. However, nuclear plants do produce radioactive emissions, the release of which must be strictly limited if adverse effects to the health of humans and other biota are to be avoided.

In the normal operation of the incremental nuclear generating units, there would be very small amounts of radionuclides discharged in the cooling water and in gaseous plant effluents. But, assuming that present standards will be maintained and enforced (these limit the release of radioactivity to no more than would expose an individual at the plant boundary to 1 percent of the individual maximum allowed), the effects of the amounts released are likely to be negligible, as the average additional annual dose which the affected population would receive would be three to four orders of magnitude less than the average level of natural radiation exposure.

The operation of nuclear plants poses some risk of accidents. Nuclear plants are designed to minimize accidents or their adverse effects if one does occur, utilizing a "defense-in-depth" principle. This includes designing and constructing plants in such a way that the number of backup safety features would depend on the risk of the potential failure and siting reactors away from areas of high population density. Plants are designed to withstand a design basis accident (DBA), defined as the worst malfunction considered to have a probability of occurrence high enough to warrant corrective action. For light water reactors, the worst DBA considered is usually a major rupture in the reactor cooling system or primary system. The maximum radiation dose which could be received at the site boundary if such an accident occurred is estimated for some plants to approach the annual doses obtained from natural radioactivity.

The ability of emergency measures to operate as planned if a loss-of-cooling accident did occur is disputed. Some responsible critics have suggested the need to consider additional safety precautions. With this uncertainty, the operation of many nuclear plants over an extended period of time can be considered to pose some risk of severe effects (ranging up to large numbers of injuries and deaths) with a very small probability of occurrence.

(6) Transportation

The nuclear fuel cycle from mining and milling through fuel preparation, powerplant use and reprocessing to the final storage of waste materials requires the transportation of radioactive materials by truck or rail

at many stages. The transportation of spent fuel elements from reactors to reprocessing plants and of high-level wastes from reprocessing plants to storage sites poses a potential environmental hazard. Existing transportation regulations and cask designs have been developed to insure that even if accidents in transporting these materials do occur, no radioactivity will be released into the environment. For the transport of the spent fuels and high-level wastes associated with as much as a 20,000 MW capacity, a small number of accidents could be expected to occur during a 25-year operating life. Although designed to prevent adverse environmental impacts, the release of radioactive substances as a result of transportation accidents remains even though the probability of such an occurrence is small.

(7) Fuel Processing and High-level Waste Storage

Spent fuel assemblies from reactors are first partially cooled and then transported to fuel reprocessing plants where usable nuclear fuel materials are recovered from them. If 2,000 MW of additional capacity were built, fuel reprocessing possibly could be accommodated at existing plants. The 7,000-20,000 MW additional nuclear capacity that could substitute for geothermal development probably could be accommodated within projected plant development plans by the time such service would be required.

With present techniques, radioactive emissions during reprocessing are approximately 100 times greater than those occurring during normal power generation. For the period being considered, permissible release levels may be reduced. Even if they are not, the estimated dose to the affected population is still two orders of magnitude below natural levels. Hence, the impact of these emissions is not expected to be significant even though the chronic effects of such low-level radioactivity are not yet wholly known.

The high-level radioactive wastes remaining after reprocessing are first concentrated and stored in solution for five years, then evaporated to solids, sealed in containers, and put into long-term storage. The 2,000 MW of capacity would produce around 16,000 to 21,000 gallons of high-level waste per year, demanding a cumulative storage capacity of 80,000 to 100,000 gallons. This liquid waste, when evaporated, would yield around 160 to 220 cubic feet/year in solid waste materials.

Because of their high concentrations of radioactive nuclides with very slow rates of decay, these waste materials must be totally isolated from the biosphere for hundreds or thousands of years if serious adverse effects to all living organisms are to be avoided. Storage in salt beds is believed to pose fewer problems than any other method of storage. However, a wholly suitable site in salt beds for the permanent storage of solid waste materials has not yet been found.

f. Hydroelectric Power

The potential development of conventional hydroelectric capacity is limited. Of the 179,900 MW capacity estimated as potentially developable in the United States, only 30,000 MW is likely to be developed by 1990 under existing programs. The potential sites would most likely be developed to provide area load peaking capacity requirements in conjunction with fossil fuel or nuclear base load plants.

The generating potential of any hydroelectric site is a function of both stream discharge, flow regulation and the height of fall. The better hydroelectrice sites are concentrated in areas with heavy precipitation and large topographic relief. The following table shows a FPC estimate of the extent of U.S. potential and developed water power capacity as of 1970.1/

Geographic Region	Potential Power (10^3 MW)	Percent of Total	Developed Capacity (10^3 MW)	Percent Developed	Undeveloped (10^3 MW)
New England	4.8	2.7	1.5	31.3	3.3
Middle Atlantic	8.7	4.8	4.2	48.3	4.5
East North Central	2.5	1.4	0.9	36.0	1.6
West North Central	7.1	3.9	2.7	38.0	4.4
South Atlantic	14.8	8.2	5.3	35.8	9.5
East South Central	9.0	5.0	5.2	57.8	3.8
West South Central	5.2	2.9	1.9	36.5	3.3
Mountain	32.9	18.3	6.2	18.8	26.7
Pacific	62.2	34.6	23.9	38.4	38.3
Subtotal-48 states	147.2	81.8	51.8	28.5	95.4
Alaska	32.6	18.1	0.1	0.3	32.5
Hawaii	0.1	0.1	---	---	0.1
Total-50 states	179.9	100.0	51.9	28.8	128.0

Of the potential hydroelectric capacity of 179,900 MW in the United States, 28.8 percent, or 51,900 MW, was developed or under construction leaving approximately 128,000 MW developable. Of this 128,000 MW of capacity, some 32,600 MW is located in Alaska. Sparsity of population and remoteness from population centers make the economic feasibility of large hydroelectric projects in Alaska subject to considerable doubt. Of the approximately 95,300 MW of capacity yet to be developed in the conterminous states, 65,000 MW are

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1/ Statistics as of January 1971 obtained from FPC.

concentrated in the Mountain and Pacific Regions. About 30,300 MW of capacity potential could be developed in the remainder of the United States.

The 38,300 MW hydroelectric capacity estimated as being developable in the Pacific States is of the magnitude that could be considered as a short-term substitute for geothermal power. At the 298 MW level, a single medium-sized power project could substitute for geothermal; at the 1,000-2,000 MW level, a project of the scale of the existing Grand Coulee plant on the Columbia River (2,276 MW) would be required; and at the 7,000-20,000 MW level, several large projects would be required as a substitute. Since those hydroelectric power projects which are economically feasible will be built to meet increasing needs of the West Region, such development does not appear to represent a viable long-term alternative to geothermal resource development.

It should be noted that few dams are built solely for hydroelectric power generation. Irrigation, navigation, municipal and industrial uses, as well as flood control, are important and frequently are the dominant objectives for the project.

(1) Hydroelectric Systems

Conventional hydroelectric developments convert the energy of natural or regulated streamflows falling through heads created by dams and waterways to produce electric power. Plants are classified as run-of-river or storage projects, depending on the way in which available streamflow is utilized. Although most of the best available sites for economical production of hydroelectric energy have been developed, some additional capacity will be provided by new sites or expansion of existing plants. Use of hydroelectric power to service peak loads enhances project benefits, permitting consideration of possibilities which formerly were marginal or uneconomic under higher capacity factor standards. Multipurpose benefits such as recreation, water supply, fish and wildlife enhancement and flood control justify projects that would otherwise be uneconomic for a single purpose.

Pumped storage projects generate electric power by releasing water from an upper to a lower storage pool and then pumping the water back to the upper pool for repeated use. During off-peak hours when project capacity is not required by the system, water is pumped to the upper pool using energy generated by other sources, usually steam-electric units. A pumped storage project consumes more energy than it generates. Its economic advantage comes from converting low-cost, low-value off-peak energy to high-value peak capacity and energy, and from the highly flexible peaking power it makes available. Pumped storage projects may be designed exclusively as pumped storage or may be included in the design of a conventional hydroelectric installation. The availability of pumped storage sites largely depends on topography which allows development of a high head between two reservoirs in the same area. In many parts of the country, there are virtually unlimited physical opportuninies for developing pumped storage projects. However, only a limited number of sites have been investigated.

The investment in hydroelectric projects per kilowatt of installed capacity varies greatly according to the type of project, size and location, the cost of lands required, and the cost of relocation of highways, buildings, railroads and other improvements. The capital costs of powerhouse and equipment per unit of installed capacity decrease with an increase in head. The unit cost at a particular site is less if large capacity units are installed rather than more units of smaller size.

Excluding pumped storage, average investment costs per kilowatt are substantially higher for hydroelectric plants than for thermal-electric plants. Capital costs of hydroelectric plants range from $200 to $400 per kilowatt of installed capacity. Total capital costs of conventional plants built in the 60's ranged from about $40 million for capacity of about 200 MW to $200 million for capacity of about 700 MW. On the other hand, hydroelectric operating expenses are much lower, largely because no fuel is required and other operating and maintenance costs are less.

Pumped storage plants have low capital costs ranging from $100 to $150 per kilowatt installed and low maintenance costs. Total capital costs are $30 million or more.

(2) Projected Hydroelectric Development

The Federal Power Commission's 1970 National Power Survey projects United States electric generation capacity to increase from 340,000 megawatts in 1970 to 1,260,000 megawatts in 1990. Conventional hydroelectric capacity for the comparable period is shown as 52,000 megawatts and 82,000 megawatts respectively. Pumped storage was projected to increase from nearly 4,000 megawatts in 1970 to 70,000 megawatts by 1990. Detail by FPC regions and years is shown in Table IV-25.

The predomination of pumped storage over conventional hydropower in new construction can be seen in the following percentages calculated from this table:

Year	Conventional hydro as percent of total electrical generating capacity	Pumped storage as percent of total electrical generating capacity
1970	15.2	1.1
1980	10.2	4.1
1990	6.2	5.6

In 1972, the Department of the Interior made the following projection for hydropower development that includes both hydro and pumped storage plants:

Table IV-25

Conventional Hydropower, Pumped Storage, and Total Electric Generating Capacity by Region

Year		Total electric generating capacity	conventional hydro capacity	pumped storage capacity
1970	Northeast	64.9	5.8	1.8
	East Central	55.0	1.0	0.1
	Southeast	63.7	9.3	0.1
	West Central	42.6	3.5	0.4
	South Central	48.9	2.3	0.1
	West	64.9	29.7	1.1
	Total contiguous U.S.	340.0	51.6	3.6
1980	Northeast	113	7	9
	East Central	103	2	4
	Southeast	132	11	4
	West Central	82	3	2
	South Central	106	3	3
	West	129	42	5
	Total contiguous U.S.	665	68	27
1990	Northeast	201	7	19
	East Central	186	3	14
	Southeast	255	13	13
	West Central	152	3	4
	South Central	211	4	8
	West	255	52	12
	Total contiguous U.S.	1,260	82	70

All units are thousands of megawatts.

Source: Data taken from National Power Survey, 1970, Federal Power Commission, Part I, Pgs. I 18-20-29.

	Installed Capacity (MW)			Net Generation (billion KW hrs)	
Year	Total Electric Utility 1/	Hydropower	Hydropower as a percent of total electric utility capacity	Total Electric Utility	Hydropower
1971	367,395	55,898	15.2 %	1,614	266
1975	480,000	80,000	16.7	2,130	350
1980	660,000	95,000	14.4	3,000	420
1985	915,000	120,000	13.1	4,140	470
2000	1,880,000	200,000	10.6	9,010	700

Source: United States Energy Through the Year 2000, U.S. Department of the Interior, December 1972, p. 26

1/ Excludes industrial generation for private use.

(3) Environmental Impacts

Numerous environmental impact statements filed by the Bureau of Reclamation of the Department of the Interior and by the Corps of Engineers describe environmental impacts of specific hydroelectric projects. Each proposed site must be individually evaluated as potential impacts vary widely.

Construction of a hydroelectric dam represents an irretrievable commitment of the land resources beneath the dam and lake (agriculture, minerals, wildlife habitat, free-flowing river recreation, etc.). Alteration of river flows may lead to silting behind the dam, thus progressively reducing reservoir capacity and its effective use, and finally, after many years, filling of the lake. Alteration of downstream flows from powerplant discharges can cause scouring of river banks and bottoms.

Construction activity increases the dust in the air and creates noise. However, operation of the hydroelectric powerplant produces no air pollution, radioactivity nor waste heat. Construction often results in temporary increases in stream turbidity. The newly-filled reservoir usually has a low dissolved oxygen content and a tendency toward nitrogen supersaturation. Reservoirs concentrate salt due to evaporation. They may decrease downstream turbidity due to settling in the reservoir; otherwise, water quality impacts are nominal.

Impacts on land and water resources tend to be limited to the vicinity of the power generation site. Dams valuable for hydroelectric purposes may also be useful for such needs as irrigation and flood control. Lakes behind dams created for hydroelectric purposes provide recreational opportunities such as swimming, fishing and boating.

Fish and wildlife habitat may be adversely or beneficially changed. The reproductive habitats of anadromous fish may be severely altered by dam construction unless elaborate provision is made for fish ladders or other means to provide safe fish passage. Significant mortalities of resident and anadromous fish in rivers servicing hydroelectric dams can be caused by gas-bubble disease resulting from exposure to nitrogen supersaturated water. Nitrogen supersaturation results at a dam when excess river flow must be passed over the spillway.

Survival studies conducted in 1971 indicate that high nitrogen levels in the Columbia and Snake Rivers pose a serious threat to the future of the salmon and steelhead resources of the region. 1/ Under present plans to expand the Columbia Basin hydroelectric system through 1980, the volume of spills at the various projects will be reduced. However, without additional control measures, the reduction in volume of spills will not be great enough to reduce nitrogen supersaturation to levels considered safe for fish during years of average or higher flows.

The Corps of Engineers is actively engaged in studying and testing several approaches to the solution of the nitrogen problem. Efforts have been concentrated on manipulation of storage, full use of generating units, slotted intake gates, collection and transportation of downstream migrants, and spillway modifications.

Running water fishing opportunities would be eliminated by flooding of the river bed. However, overall fishing opportunity may be greatly expanded as a result of the large water impoundment area, its ability to maintain large fish populations and the ease of public access and use of such reservoirs. Wildlife habitat is reduced to the extent that lands are flooded but provision can be made for replacement habitat improvement if the habitat loss should be significant.

1/ Power Planning Committee, Pacific Northwest River Basins Commission, Review of Power Planning in the Pacific Northwest, Calendar Year 1971, pp. 71-76., submitted by Idaho State Director, Bureau of Land Management.

g. Other Energy Sources

There are other potential energy sources which need to be recognized as possible energy alternatives to geothermal power development. At present these alternatives are not considered viable due to a lack of proven technology for production scale application, costs, timing of development, location relative to energy demand, environmental impacts, etc. These include hydrogen, magnetohydrodynamics, fuel cells, thermionic generation, tidal power, wind energy, solar energy, and biological conversion of wastes to oil.

Potential environmental impacts of these alternatives are difficult to assess, particularly where there is a great amount of research and development that must be done before operational scale systems can be developed, tested, evaluated and readied for production application. It is not believed that any significant energy production can be obtained from these systems. Essentially, these are all in the research and development stage and, while some discussion of potential environmental impacts is included, it is not possible to develop a full discussion due to the lack of necessary data. The following sections briefly describe the current and short-range status of each of these potential alternatives.

(1) Hydrogen

The basic technology of using hydrogen as an alternative to fossil fuels exists but it is energy intensive. This could be a major obstacle to economic development of this relatively pollution free source of energy, as it would require commitment of energy already needed for other purposes with a significant conversion loss. By passing an electric current through water in a process called electrolysis, water can be separated into its components oxygen and hydrogen. The hydrogen can be transmitted by pipeline or liquified and shipped by tank car for use as a fuel substitute for other liquid or gaseous fuels.

Prior to 1958, liquid hydrogen was produced only in small quantities and was primarily a laboratory curiosity. The 1972 U.S. hydrogen production was more that 12 billion pounds for use primarily in making refined petroleum products and chemical synthesis. Only a small fraction of this total production comes from the electrolysis of water, the great preponderance being produced by cheaper methods of breaking down natural gas, oil and to a lesser extent coal through various catalytic systems and partial combustion processes.

Future speculations for massive hydrogen producing facilities include great floating platforms offshore in the oceans. These platforms would house a series of nuclear powerplants which would generate power for decomposition of sea water by electrolysis, the hydrogen produced could be piped ashore. The potential advantages of such a system could be numerous.

Hydrogen gas could be piped to its point of use at about one-eighth the cost of sending an equivalent amount of electricity through high voltage overhead cables. Underground pipe transmission of gaseous hydrogen would eliminate unsightly overhead wires. Unlike electrical capacity which is difficult or inefficient to store, hydrogen could be stored as a gas in underground cavities or as a compressed liquid in large insulated tanks to meet fluctuating power demands. Already under development are fuel cells which convert hydrogen and oxygen directly into electricity. Advanced electrolytic cells are also under development which catalytically decomposes water into oxygen and hydrogen at a 1/4-1/3 reduction in electrical power requirement.

The major advances made in hydrogen technology in the last decade are largely a spin-off of rocket and space programs. Liquid hydrogen engines have powered astronaut crews safely to the moon and back. In the future these engines are scheduled to play an even larger role in the space shuttle.

The economics and timing of hydrogen's first use as a fuel are complex matters. Presently liquid hydrogen is only about 50 percent more expensive than gasoline on a Btu per unit weight basis since liquid hydrogen is so much higher in energy content. Actual cost projections for the electrolytic production of hydrogen range from a low of $0.04 per pound using electrical energy from a large breeder type reactor to about $0.12 per pound for other energy sources. Presently gasoline costs of production are about $0.02 per pound. Hydrogen gas is so light it cannot match natural gas in heat value on a volumetric unit basis. The first hydrogen gas should enter the economy in hybrid gas mixtures that stretch natural gas supplies or may be mixed with synthetic gas products from coal perhaps before 1980. It is possible to convert present gas lines to handle hydrogen although at considerable changeover costs. Transmitting costs of the lighter gas would double or triple; there would be need for tighter more carefully maintained piping systems. The lighter gas could move more rapidly.

With some mechanical modifications all types of internal combustion engines can burn hydrogen cleanly. In the summer of 1972 at the Urban Vehicle Design Competition of 63 experimental cars, the 2 least polluting cars were those converted to run on hydrogen, one of which was the only car to exceed the 1975-76 Federal emission standards. Buses, trucks, ships, locomotives also could run on hydrogen with their present engines although somewhat less efficiently. It also could be burned in the home for heating or cooling. In any combustion of hydrogen as a fuel, the only major waste product is water. Additional uses, as the direct reduction of iron ore, dispense with coal and coke use as is already being done at several small scale plants. Production of high temperature steam for conventional steam power plants is also a future possibility.

Conversion costs would be extremely high particularly to the consumer. Enormous investments of capital will be necessary as well as demonstration projects to work out technical problems. It is possible that the use of

hydrogen as a fuel could be substantial by the mid-80's. Large amounts of energy needed for electrolysis could presently be provided only by fossil fuel which would not relieve energy supply or environmental problems.

Projections of this alternative remain highly speculative due to its largely experimental nature and its early stage of development.

(2) Magnetohydrodynamics

Magnetohydrodynamics (MHD) power generation is a technique for electrical generation which passes a hot, ionized gas or liquid metal through a magnetic field. Such a high-temperature, one-stage conversion device has the potential of high overall efficiencies. Although the concept of MHD generation has been known for over 100 years, it is only during the past decade that significant technological advances have produced systems which offer promise for future use in the electric power field.

Three basic approaches to MHD generation are being explored: open-cycle, closed-cycle, and liquid metal systems.

The MHD open-cycle generator, used as a "topping unit" in conjunction with steam-turbine generators, appears to hold the most promise for MHD central-station power production in the near future. Overall system efficiency is expected to increase to a range of 50 to 60 percent over fossil fuel steam-electric plants. General application of coal-fired MHD topping units by the mid-1980's could effectively extend fossil fuel reserves and enhance the potential for use of coal for power generation. Since the MHD generator would require little cooling water, the combined MHD-steam units would require considerably less cooling water per megawatt of capacity than conventional fossil fueled or nuclear steam-electric units.

Before MHD can be utilized for central power station generation there are many significant technological problems which must be solved. No economically practical system has yet been demonstrated for burning coal or coal-derived fuels. Designs to date have been small scale with short lifetimes and lower efficiencies than would be required for utility operation. There are problems associated with developing high-temperature electrodes, superconductivity magnets, seed recovery systems, and procedures for coping with high temperature metal erosion and corrosion, etc. The high temperatures and gas passage time are conducive to fixation of nitrogen so there may be significant NO_x air quality problems.

Some environmental problems would be reduced due to decreased fossil fuel requirements of MHD generators, such as impacts from fossil fuel production,

thermal water discharges, and total noxious atmospheric emissions. There are environmental impacts inherent to MHD generation and to the total electrical energy demand increases which will create offsetting environmental problems. High temperature operations create specific NO_x emission problems. Coal-powered MHD generators and increased power demands will lead, in time, to increased coal production with attendant environmental and worker health and safety problems. Transmission of electrical power or transportation of coal at some point in the fuel-generator-consumer chain will create land use, aesthetic, and associated environmental problems as discussed in previous sections.

While MHD appears to offer considerable future potential for coal-fired power generation, the technologic and economic uncertainties are still so great that it cannot now be considered as a viable alternative power source to geothermal development. (For additional detail, see Chapter IX of the Federal Power Commission's National Power Survey Report, December 1971).

(3) Fuel Cells

Fuel cells are electrochemical devices in which the chemical energy of fuel is converted continuously and directly to low-voltage direct current electricity. The basic process is similar to that of a battery except that the fuel cell is an open system requiring a continuous supply of reactants for the production of electricity. The potential advantages of a fuel cell over more conventional energy conversion systems are its quietness, low temperature of operation, minimization of pollution, reliability, and greater efficiency (up to 70 percent). Nearly one and one-half times more electrical energy can be obtained from a ton of coal in a fuel cell system than from a comparable amount burned in a modern, conventional power system.

Because of the current necessity for costly metal catalysts, reforming, and fuel purification processes, the near future of fuel cells, even for small power units in a mass market, is remote. General application will be feasible only when efficient units capable of using common fuels are developed.

(4) Thermionic Generation

When a metal is heated, a point is reached where its electrons acquire enough energy to overcome retarding forces at the surface of the metal and escape or boil off. When collected on another cooler metal surface, electrical energy can be generated by joining the two pieces of metal with an external circuit. Since thermionic generators are another type of heat engine, their efficiency theoretically is limited to 35-50 percent. At present, efficiencies ranging from 5 to 25 percent have been reported for test models. Commercial exploitation of the phenomenon awaits solution of difficult materials problems related to operations above 3000°F. and, in isotopic-fueled devices, radiation

damage. The Federal Power Commission 1972 National Power Survey indicates it is the consensus that future efforts in thermionic development during the next decade will be concentrated in space-oreinted activities. The principal effort will be directed to the development of nuclear-fueled systems to be used as power sources for interplanetary expeditions. There is little likelihood of thermionics achieving commercial realization for large-scale generation within the next several decades.

The state of development is not sufficiently advanced for an evaluation of potential environmental impacts. Since it is a type of heat engine, the associated loss of heat is a potential source of thermal pollution. Heat sources of fossil or nuclear fuels also would have their relative environmental impacts.

(5) Tidal Energy

Tidal power is a hydroelectric energy source similar to other water power sources except that it is derived from the alternate filling and emptying of a bay or estuary that can be enclosed by a dam. The total tidal power dissipated by the earth is enormous, largely accounted for by oceanic tidal friction in bays and estuaries around the world although theoretically it could be captured and converted to electric power. Despite this total potential, practical considerations have eliminated all geographic areas except where tidal behavior, range and water displacement are extremely favorable.

Two plants are presently operating, the larger is the Rance Plant on the Rance River estuary Brittany, France which was completed in 1967 at a cost of $90 million, a capacity of 240 MW, to be increased to 320 MW. The present cost is about $350/KW. The U.S.S.R. completed its first plant on the White Sea in 1969 which has a 1,000 KW capacity. Other proposals include the Bristol Channel U.K., San Jose Gulf. Argentina and the Western Australian Coast. The Canadian Government studied 23 sites on the Bay of Fundy, with its potential included below:

(New Energy Task Group, 1972)

POTENTIAL TIDAL ENERGY

	Bil. KWH/Yr
Passamaquoddy Bay, U.S./Canada	1.8
Cook Inlet, U.S.	75
Bay of Fundy, Canada	
Three sites, single effect	13.4
Three sites double effect (incoming-outgoing tides)	16.8
Total potential, Bay of Fundy	175

Even with the potential of the Bay of Fundy's 35 foot tides, the project was abandoned in 1969 by the Canadian Government as uneconomical.

There are two major tidal power sites in the United States which have a significant potential for such development (Bernshlein, 1965). The Bay of Fundy, Maine, with nine sites, including many on the Canadian side, has an average potential power capacity of approximately 29,000 MW and Turnagain Bay in Cook Inlet, Alaska, has an estimated potential power capacity of 9,500 MW. The distance from population centers makes the Turnagain Bay site doubtful from an economic standpoint. If the Bay of Fundy capacity were developed with half of the production going to Canada and half to the United States, the total addition to U.S. capacity would be some 15,000 MW. This would represent approximately 1.1 percent of generating needs by 1990. Capital costs as high as $1 billion for the 1.8 Billion kwh/yr were calculated in a detailed 1964 Senate Subcommittee proposal for development.

The major technological problem associated with the development of tidal energy would be the need to develop turbines able to operate economically under low hydrostatic heads (U.S. Department of the Interior, 1972). The Bay of Fundy potential of 15,000 MW is comparable to the 7,000-20,000 MW estimated geothermal potential; however, it could not be considered substitutable owing to the distance from Fundy to the West Coast. The overall impact of tidal power on the U.S. energy supply would be minimal in that it does not represent a significant alternative to the need to develop other energy sources.

There would be significant environmental considerations associated with the damming and alternate filling and emptying of bay and estuary areas, such as impacts on sport and commercial fisheries, wildlife, water quality, recreation uses, other land uses, shipping and aesthetic values.

(6) Wind Energy

The energy in wind is the result of a mass of moving air. To capture such energy requires placing in the path of the wind a machine which transfers the wind force to the machine (Golding, 1958). There is a wide range of estimates as to what the energy potential might be; one figure is 20,000 MW at elevations low enough for extraction by aerogenerators (wind turbines). This figure reflects an ultimate potential but it has little bearing on the degree to which this resource can be utilized. Economical power generation requires an average annual wind velocity of about 30 m.p.h. with nearly steady magnitude and direction and topography in which boundary-layer effects are minimal.

Although there are many locations that appear suitable for aerogenerators, their use would be contingent largely on the development of low-cost generators, a site amenable to low-cost installation, a favorable overall wind speed, and an electric grid capable of profitably using an interruptible power of this nature.

Potential advantages in using wind energy are: (a) the supply is inexhaustible; (b) it is available in many parts of the world; (c) the energy source is free on the site of production. Some of the disadvantages are: (a) the low energy density of the wind; (b) the wind velocity is unpredictable in time and magnitude; (c) the low conversion efficiencies of aeromotors; (d) the effect of icing conditions and weather on aeromotors.

In Denmark between 1940-1945 when fuel oil was in short supply, 88 wind-driven installations generated 18,000 MWH for local needs. In 1970, the International Telegraph Telephone Consultive Committee listed the following existing large-scale wind-driven generator installations:

Country	Location	Date	Capacity KW
U.S.S.R.	Balaclava	1931	100
U.S.A.	Vermont	1941	1,250
Denmark	Gedser	1959	200
United Kingdom	Orkney	1952	100
United Kingdom	St. Albans	1954	100

By combining wind-driven generators with diesel standby units continuous, small-scale, dependable power can be locally generated. This method has supplied lighthouses for over ten years at several locations, but at a capacity of less than 10 KW. Presently there is only one major research project to harness the wind's energy at the University of Hawaii with a budget of just over $100,000/Yr. If, for example, 10 billion KWH/Yr could be produced from a few large and numerous small generators then it would reduce the use of conventional fuel annually by 4 million tons of coal, 300 MW of geothermal generating capacity, or another equivalent source of energy. However, high equipment, energy storage, and back up equipment costs coupled with the intermittent characteristics of the wind preclude a favorable cost benefit of wind energy at the present time. Small-scale use may increase in remote areas where transmission costs prevent conventional power systems, but this impact on the total power picture is negligible.

Wind energy does not appear to be a viable alternative to traditional large-scale energy sources at this time as a considerable amount of additional research and development is required. However, there are those who feel that substantial electrical energy production is possible now from lower velocity winds and the use of technology developed in past research projects even though there has not been major activity toward commercial development of wind energy for several years (Heronemux, 1972).

Since the use of the wind for power generation is in itself a pollution free source of electrical energy that would replace the need for fossil fuel or nuclear generation, there would be an environmental benefit that would be generally in direct ratio to the adverse environmental impacts of the alternative electrical energy generation source displaced.

A primary environmental disadvantage could be the aesthetic effect of a large number of towers at prominent locations with heights of as much as 1,000 feet, topped with large generators turned by wind turbines with blades of 50 to 200 feet in length or longer. Previous large-scale efforts have failed due to structural factors so towers probably would require heavy guying. There would be land surface impacts resulting from the construction and operation of numerous generator sites and access thereto. Since each tower would have to be serviced by transmission lines and related structures to connect the wind generation grid into power grids, there could be considerable environmental disturbance associated with the development and operation of such lines.

(7) Solar Energy

Although the solar energy density is low, the United States land area intercepts each year about 600 times its total 1970 energy requirements. Such heat could be used for electricity generation, space heating, cooking, and processing of industrial materials. The electromagnetic properties of solar radiation produce photosynthetic conversion and storage of energy in plants and other photochemical reactions which also convert and store energy.

Four characteristics of solar energy deserve particular notation:

(a) It is a diffuse, low-intensity source of energy

(b) The energy is spread over various frequencies (i.e., distributed over the various wave lengths of light)

(c) Its intensity is continuously variable during the daylight hours, is zero at night, and is subject to weather and seasonal variations

(d) Its availability differs widely between geographic areas

A consequence of the diffuse nature of solar energy is that it does not naturally produce the high temperatures characteristic of combustion processes. This is a definite disadvantage since high temperatures make possible greater thermodynamic efficiency in energy conversion.

About half the energy in the solar spectrum lies in wavelengths usable in photosynthesis. The efficiency of this half can be in the neighborhood of 50 percent, giving an overall possible photosynthetic conversion of 25 percent. In experiments, efficiencies in the usable spectrum ranged from chlorella (a green algae) at 20 percent conversion efficiencies to about 2 percent for sugar can.e Experiments in Japan to use chlorella have always fallen short of economical use as food. Consequently, using it for fuel with a lower unit value than food would also be uneconomical. Since chlorella rates high in efficient conversion of solar energy, other plants do not appear to hold good prospects for useful conversion of solar energy.

The number and range of potential solar applications are extensive but the present state of the art is such that energy collection efficiencies are low, and the requirements for energy storage resulting from the intermittent nature of the source result in costs that are prohibitive for general use. A typical 2,000 MW powerplant operating in a 1,400 Btu/day solar climate would, with present technology, require 74 square miles of collector surface (assuming a 30 percent efficiency in converting solar energy to process heat and 5 percent when converting to electrical energy). The many square miles of collector surface that would be required for even a medium-sized power generation facility would have significant impact on the land area, its other use or resource values, and on the general environment. There would be a major aesthetic intrusion in desert areas which are now generally unmarred by man's activities.

Such large collector areas and low efficiencies make it unlikely that solar energy will have any significant impact as a large-scale source of power within the next 30 or more years as the economics and environmental considerations are very unfavorable compared to many other alternatives. Even a 300-percent increase in the solar cell efficiency would not result in power costs that would be economically acceptable for general use. A massive research and development effort over an extended period of time would be required to lower costs, increase conversion efficiency, and achieve acceptable system performance.

The silicon cell, developed about 15 years ago, has proved to be a reliable means for this direct conversion of solar radiation to electricity for applications in outer space. The generation of significant amounts of power, however, requires the connection of extremely large numbers of cells. The capital cost of silicon cell arrays results in power costs on the order of $2.00 to $5.00 per KWH. Thus, the cost is about 1,000 times that of conventional power sources.

Examples of other types of solar generation potential include floating powerplants which would use the solar produced temperature differentials which exist between the upper and lower levels of Caribbean waters and the Gulf Stream. A second concept deals with the orbiting of space vehicles

for the purpose of creating central power generation. Systems such as these have not yet been developed or tested so they do not represent feasible energy source alternatives that can be considered at this time.

Some application for solar heat exists in home heating using relatively inexpensive collectors costing $2.00 to $4.00 per square foot and using auxilliary heating when necessary. Table IV-26 summarizes a 1967 cost study relative to such application. Such localized use, although intriguing, is not likely to reach general acceptance for heating homes before 1985 with fossil fuel systems so inexpensive and convenient.

As a large scale source of power, expensive collector areas and low efficiencies make it unlikely that solar energy will have any significant impact within the next 30 years as the economics are unfavorable compared to many alternatives.

(8) Biological Energy

Biological energy has attractive prospects in two major areas. One is the production of alcohol from crops, particularly unused crop surpluses, and the other involves the conversion of organic wastes into usable oil.

The efficiency of U.S. agriculture has advanced so fast that for several decades crop production has exceeded demand except in times of international conflicts and in early 1973 when heavy international buying, coupled with unusually bad weather, drained surplus stores. Average farm production has increased about 80 percent in the last three decades, largely owing to better yielding seeds and greatly improved "know-how." Thus, to meet our crops needs, we plant fewer acres and require fewer farmers. 1/

Agriculture provides the major current source of renewable energy. Forests, cultivated crops and pasture land may be used repeatedly under proper management. Agricultural production is, however, subject to weather, diseases, wind and other natural conditions which cannot yet be completely controlled. Nevertheless, average production in excess of priority requirements for domestic food, feed and fibers is believed possible by 1985 and beyond, barring natural disasters or national emergencies. The production of cereal grains and their conversion through fermentation to usable ethyl alcohol fuel; the collection and use of such residues as straws, corncobs, hulls and shells for fuels; the growing of crops for fuel energy; and the conversion of animal by-products into fuels are all possibilities.

Agricultural fuels would normally be more expensive than such traditional fuels as coal, gas, oil and waterpower. Increasing U.S. needs for energy, requirements for pollution abatement and many other economic factors could, however, materially change the future role of agriculture as a source of industrial energy.

1/ New Energy Forms Task Group, 1971-1985, Other Energy Resource Subcommittee on National Petroleum Council Committee on U.S. Energy Outlook, 1972.

Table IV-26

Solar Heating Cost Comparison

(dollars per 10^6 Btu)

Climate classification	Solar heat	Electricity	Gas-Oil (average)	Fuel cost only 75% combustion efficiency
Santa Maria: Mediterranean or dry summer, subtropical	1.10-1.59	4.36	1.52	
Albuquerque: Tropical and subtropical steppe	1.60-2.32	4.62	1.48	
Phoenix: Tropical and subtropical desert	2.05-3.09	4.25	1.20	
Omaha: Humid continental, warm summer	2.45-2.98	3.24	1.18	
Boston: Humid continental, cool summer	2.50-3.02	5.25	1.75	
Charleston: Humid subtropical	2.55-3.56	4.22	1.26	
Seattle/Tacoma: Marine west coast	2.60-3.32	2.31	1.92	
Miami: Tropical savannah	4.05-4.64	4.90	2.27	

Source: The International Telephone and Telegraph Consultative Committee, 1970 Primary Sources of Energy.

Of the approximately 2,260 million acres of U.S. land available, about 25 percent is classified as forest and woodland and about the same proportion is land suitable for cultivation. Most of our woodland will probably be required to meet the predicted demands for lumber, pulp and paper industries, and thus will offer only minor possibilities for contributing to additional U.S. industrial energy supplies. On an average, however, only about 60 percent of the potentially available cultivated land is now farmed for crops. Yields of cereal grains on these lands have, on an average, increased about three percent annually for the past decade. This increase has exceeded the U.S. population growth, even though the amount of cultivated land has decreased. Thus, unused acres constitute a potential source of energy for the foreseeable future.

A logical sequence of energy conversions is to use this land to produce cereal grains, which are largely carbohydrate, and then to convert these grains by fermentation into ethyl alcohol, which is a convenient combustible fuel readily usable in motors. If we assume that the 100 million acres, or about one-half of the acres now required, are used to produce the grain for alcohol at a yield of 70 bushels per acre, this would be equivalent to about 18 billion gallons of alcohol, or over 20 percent by volume of the 86 billion gallons of motor fuel consumed in the U.S. in 1970. Since ethyl alcohol contains only 65 percent of the energy content of gasoline, on a gallon basis, the actual energy replacement would be only 14 percent.

The cost of this ethyl alcohol from fermentation would be many times higher than the cost of present motor fuel. Even so, this tremendous energy potential must be considered in any assessment of future energy sources.

The quantity of organic waste generated in the United States annually is enormous and will continue to increase. The Bureau of Mines has summarized various amounts of wastes produced and amounts available as well as potential for conversion into oil and gas (Table IV-27).

According to the study, 1971 collectable agricultural residues in the U.S. amounted to over 125 million tons annually with an oil potential of 170 million barrels, roughly equivalent to 47 million tons of low sulfur coal. To produce the oil from waste, the organic material is treated with carbon and water at 250°-400° C and 2000-5000 psi pressure. This oil product has a heating value of 15,500 Btu per pound and the total energy potential would be on the order of 2000 trillion Btu. High collection and processing costs, incomplete technology, along with high capital requirements, prevent this energy source from being economically competitive.

Bureau of Mines research (Appell and other, 1971) has shown that it is possible to convert such organic wastes to oil with a potential of 1.25 barrels of oil per ton of waste. If all this waste could be converted to oil it would represent over 1.3 billion barrels of oil a year. This compares with a 1970 petroleum demand of 5.4 billion barrels. However, it

TABLE IV-27

ESTIMATES OF ORGANIC WASTES GENERATED - 1971 AND 1980

Source	1971	1980	1971 1/
	(Million tons per year)		
Manure	200	266	26.0
Urban refuse	129	222	71.0
Logging and wood manuf. residues	55	59	5.0
Agriculture crops and food wastes 2/	390	390	22.6
Industrial wastes	44	50	5.2
Municipal sewage solids	12	14	1.5
Miscellaneous organic wastes	50	60	5.0
Total	880	1,061	136.3
New oil potential (million barrels)	1,098	1,330	170
Net gas for fuel potential (tril cu ft)	8.8	10.6	1.36

1/ Organic solids available for conversion.

2/ Assuming 70 percent dry organic solids in major agricultural crop waste solids.

must be recognized that even if this preliminary technology could be developed to commercial feasibility, only a fraction of the organic wastes could be collected with a reasonable amount of cost and effort for application of this process. Nevertheless, its use does have the potential of providing a significant supplemental source of oil. The process lends itself to essentially pollution-free operation while at the same time offering a solution to a portion of the problem of solid-waste disposal. The oil so derived has a low-sulfur content and a high-heating value. If only half of the organic waste could be converted to oil, it could supply an amount equal to the current volume of residual fuel oil now used for electrical generation.

Preliminary research has been done in closed, batch autoclaves. Currently, a continuous unit with a capacity of 20 pounds per hour is being operated.

To use animal waste for conversion to fuel would have the obvious advantages of disposing of a pollutant itself and recycling it into a useful product. Areas of high population density produce greater wastes and would have a locally available source of fuel in proportion to their population. Water quality problems associated with organic wastes could be alleviated. The residue would be sterile although large amounts of bulk material would still have to be placed somewhere, perhaps as land fill.

The oil produced has properties varying with the type of material composing the waste. Bureau of Mines studies indicate that the sulfur contents of oils produced from various sludges would meet the Federal fuel standards of 0.7 percent sulfur.

	Percent Sulfur
Pineneedles and twigs	0.10
Sewage sludge	.64
Municipal refuse	.13
Cow manure	.37
Cellulose	.003-0.2

A distinct advantage in waste conversion would be to reduce demand on natural resources commensurate with the amount of oil and gas made from these wastes.

Considerable additional work over a period of years will be required to move from the present early stage research to demonstration-type operations at a commercial scale to prove technological feasibility and to develop adequate economic data. No cost estimate of probable commercial-scale production can be made at this time.

The process lends itself to implementation of a waste conversion process which will recycle waste to provide fuel resource values and, at the same

time, greatly alleviate many of the critical solid waste disposal situations confronting the Nation. Water quality problems associated with feedlot and agricultural wastes could be mitigated. The need for landfills or other volume forms of disposal would be greatly reduced as the solid residue from the process would consist of the mineral constituents in the original charge. Its quantity would be small and because it would be sterile it would produce no problem as land-fill material. Since the process produces a low-sulfur oil with high-heat value, it could to a limited degree replace the need for natural-oil production with a corresponding reduction in all of the related environmental hazards of such production.

h. Conservation of Energy

An alternative to a leasing program for development of geothermal steam could be accomplished by reduction of the demand for energy. Energy conservation measures may be broken down into two general categories, namely, "belt tightening" and "leak plugging." "Belt tightening" includes actions which reduce output at fixed efficiency levels. "Leak plugging" includes actions which improve the efficiency of energy use while retaining at least the present performance level.

The most significant energy conservation measures are the installation of improved building insulation; adoption of more efficient air conditioning systems; a shift of intercity freight from truck to rail and consolidation in urban freight movement; a shift of intercity passengers from air to ground travel, and intracity passengers from automobiles to mass transit; and the introduction of more efficient industrial processes and equipment. Before any of these actions could be put into effect, an assessment must be made of the environmental, economic, legal, and social impact, as well as public acceptance.

The demand for energy in the United States has been increasing at an average rate of 3.1 percent annually for the last 20 years. Energy demand in the rest of the world has grown at a rate nearly double that of the United States in recent years.

Energy demand has been closely correlated with gross national product, which, in turn, is closely correlated with both population and per capita income. The increasing use of energy has, therefore, been correlated with increasing affluence and a rising material standard of living. In part, perhaps because the economic cost of energy has not taken full account of environmental costs and because supplies of resources have been ample, growth in energy demand has been little constrained by economic considerations.

The per capita consumption, based upon a current base forecast of population (Bureau of Census, 1970, Series D), U. S. energy demand for 1971, and projection of energy demand made on a "most probable" basis by the Department of the Interior, follows:

Year	Population (million)	Selected Estimates of Total Gross Energy Consumption (trillion Btu)	Per Capita Consumption (million Btu)
1970	204.8	68,989	337
1975	216.6	80,265	371
1980	230.9	96,020	416
1985	246.3	116,630	474
1990	260.8	140,480	539

Clearly, the increase in per capital consumption is far more important to growth in energy demand than the growth in population. At zero

population growth and with no net immigration (Bureau of Census, 1970, Series X), growth trends would be:

Year	Population (million)	Selected Estimates of Total Gross Energy Consumption (quadrillion Btu)	Per Capita Consumption (million Btu)
1970	204.8	69	337
1975	216.6	80	371
1980	223.3	93	416
1985	233.2	111	474
1990	241.8	130	539

The continued increase in population to 1990, despite a zero population growth rate, is due to the age distribution and consequent fertility expectations in the existing population.

Efforts at education and encouragement of voluntary family planning are policy options, but the foregoing tables show that, even at the extreme of immediate zero population growth, the effect on total energy demand would not be great over the short-term unless prospective demand growth is slowed.

Reduction in demand is possible through implementation of conservation measures directed toward the four consuming sectors--Transportation, Residential/Commercial, Industry, and Utilities. The means of implementing these measures fall into three categories: (1) standards and regulations, (2) tax incentives (credits and penalties), and (3) educational campaigns. A recent Office of Emergency Preparedness (OEP) publication, "The Potential For Energy Conservation," dated October 1972, outlines various energy conservation measures and estimates saving of energy demand that may be realized by their implementation.

The following possible energy conservation measures for the short-term (1972-1975), mid-term (1976-1980), and the long-term (beyond 1980) for the four consuming sectors are summarized from the OEP report:

(1) Short-Term Measures (1972-1975)

Transportation - Conduct educational programs to stimulate public awareness of energy conservation in the transportation sector; establish government energy efficiency standards; improve airplane load factors; promote development of smaller engines/vehicles; improve traffic flow; improve mass transit and intercity rail and air transport; promote automobile energy-efficiency through low loss tires and engine tuning.

Savings - 1.9 QBTU/yr.[1/]

1/ Quadrillion BTU

Residential/Commercial - Provide tax incentives and insured loans to encourage improved insulation in homes; encourage use of more efficient appliances and adoption of good conservation practices.

Savings - 0.2 QBTU/yr.

Industry - Increase energy price to encourage improvement of processes and replacement of inefficient equipment; provide tax incentives to encourage recycling and reusing of component materials.

Savings - 1.9 - 3.5 QBTU/yr.

Electric Utilities - Smooth out daily demand cycle by means of government regulations; facilitate new construction; decrease electricity demand.

Savings - 1.0 QBTU/yr.

(2) Mid-Term Measures (1976-1980)

Transportation - Improve freight handling systems; support pilot implementation of most promising alternatives to internal combustion engine; set tax on size and power of autos; support improved truck engines; require energy-efficient operating procedures for airplanes; provide subsidies and matching grants for mass transit; ban autos within the inner city; provide subsidies for intercity rail networks; decrease transportation demand through urban refurbishing projects and long-range urban/suburban planning.

Savings - 4.8 QBTU/yr.

Residential/Commercial - Establish upgraded construction standards and tax incentives and regulations to promote design and construction of energy-efficient dwellings including the use of the "total energy concept" for multi-family dwellings; provide tax incentives, research and development funds and regulations to promote energy efficient appliances, central air conditioning, water heaters and lighting.

Savings - 5.1 QBTU/yr.

Industry - Establish energy use tax to provide incentive to upgrade processes and replace inefficient equipment; promote research for more efficient technologies; provide tax incentives to encourage recycling and reusing component materials.

Savings - 4.5 - 6.4 QBTU/yr.

Electric Utilities - Restructure rates for heavy uses to smooth out demand cycle; facilitate new construction.

Savings - 1.1 QBTU/yr.

(3) Long-Term Measures (beyond 1980)

Transportation - Provide R&D support for hybrid engines, non-petroleum engines, advanced traffic control systems, dual mode personal rapid transit, high speed transit, new freight systems, and people movers; decrease demand through rationing and financial support for urban development and reconstruction.

Savings - 8 QBTU/yr.

Residential/Commercial - Provide tax incentives and regulations to encourage demolition of old buildings and construction of energy-efficient new buildings; R&D funding to develop new energy sources (solar, wind power).

Savings - 15 QBTU/yr.

Industry - Establish energy use tax to provide incentive for upgrading processes and replacing inefficient equipment; promote research in efficient technologies; provide tax incentives to encourage recycling and reusing component materials.

Savings - 9 - 12 QBTU/yr.

Electric Utilities - Smooth out daily demand cycle through government regulation; facilitate new construction; support R&D efforts.

Savings - 1.4 QBTU/yr.

Advances in technology offer promise of increasing the efficiency of extraction of energy from fuels. Examples include fuel cells, magnetohydrodynamics, and breeder reactors.

A major consideration in restricting demands for energy is the relationship between the cost involved in accomplishing such restriction and the environmental damage which would be prevented thereby. In general, the cost-benefit ratio of reducing energy demand would vary considerably, depending upon the existence, the level, and the effectiveness of environmental protection measures adopted.

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